Moose
Management Report
of Survey-Inventory Activities
1 July 2001–30 June 2003

Cathy Brown, Editor
Alaska Department of Fish and Game
Division of Wildlife Conservation
December 2004

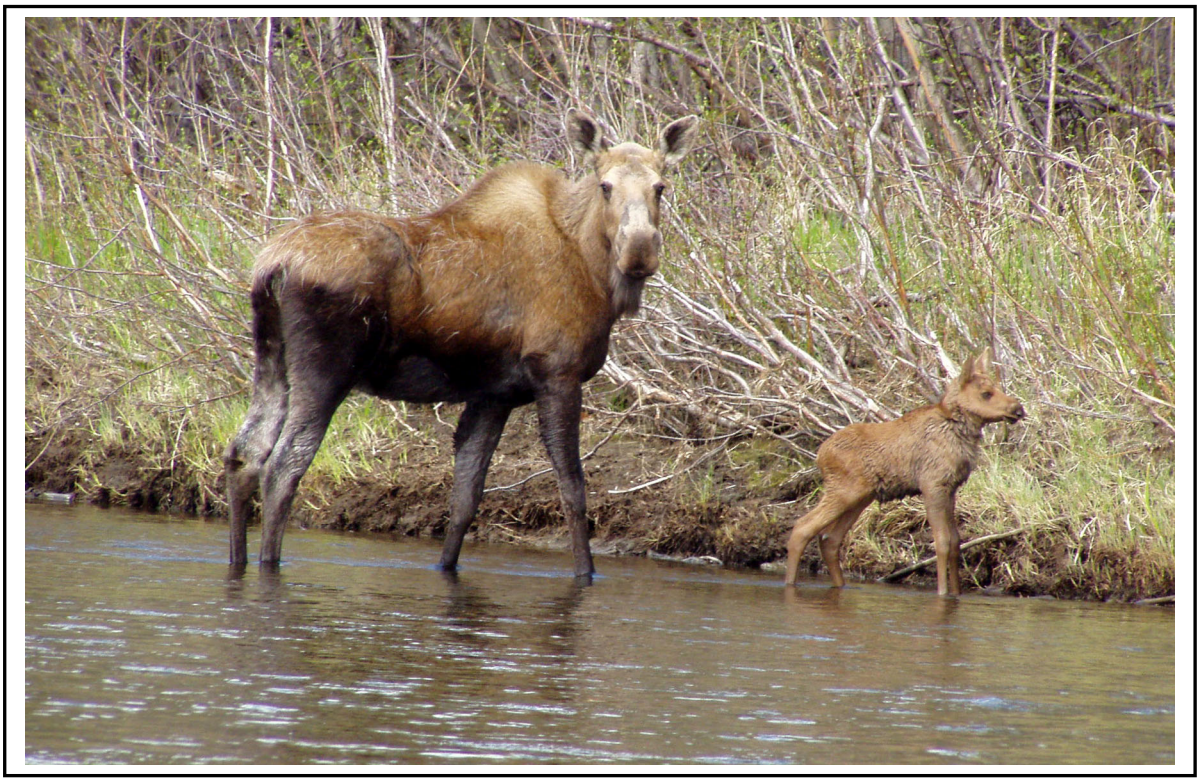

Photo by Randy Rogers, ADF&G

Please note that population and harvest data in this report are estimates and may be refined at a later date.

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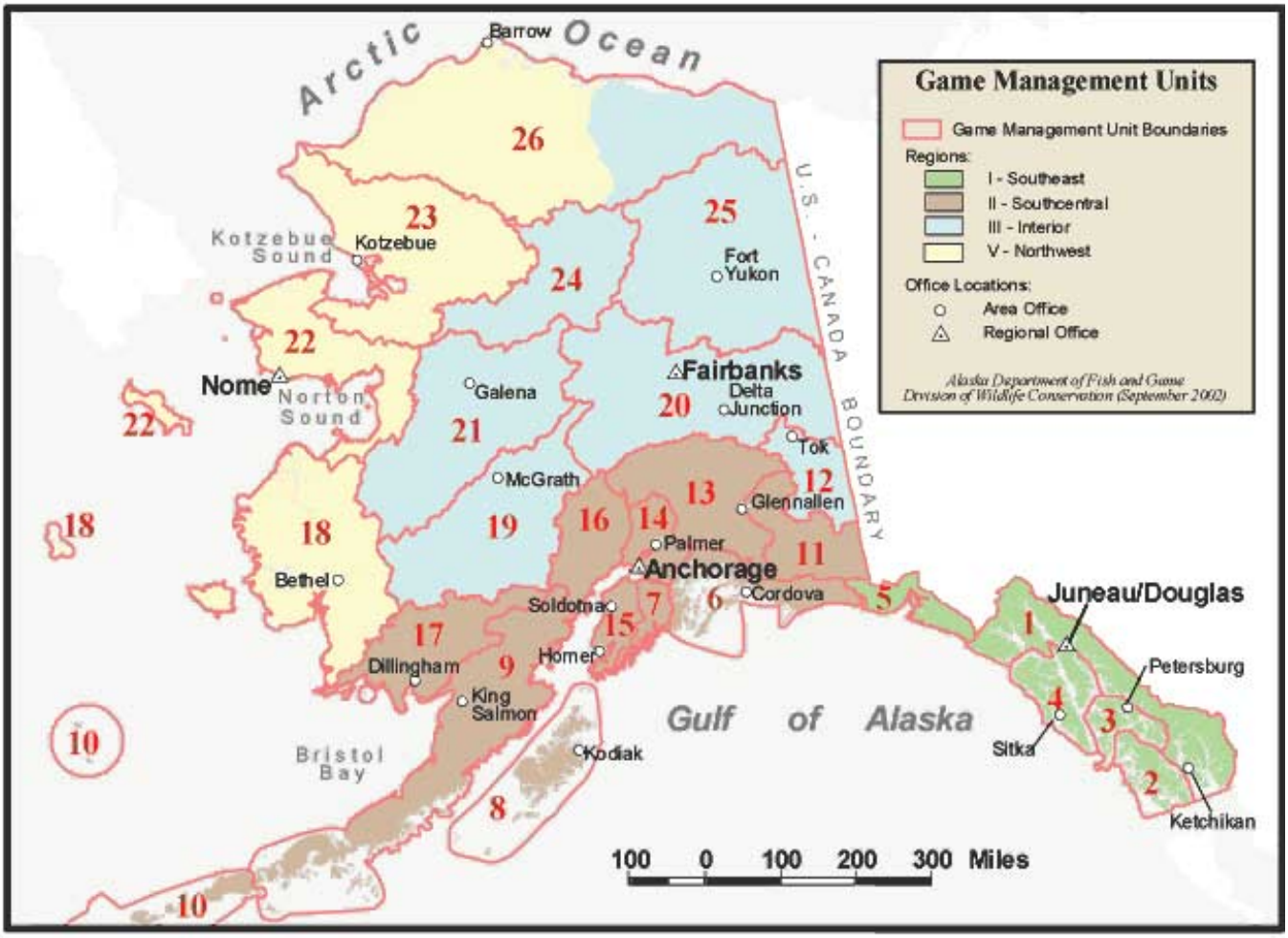
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WILDLIFE MANAGEMENT REPORT

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MOOSE MANAGEMENT REPORT

From: 1 July 2001
To: 30 June 2003[a]

LOCATION

GAME MANAGEMENT UNIT: 20A (6796 mi^2)

GEOGRAPHIC DESCRIPTION: Tanana Flats, Central Alaska Range

BACKGROUND

Moose are found throughout the Tanana Flats and adjacent Alaska Range foothills at exceptionally high densities relative to similarly sized areas throughout North America. Unit 20A moose are a world-class wildlife resource. Gasaway et al. (1983) presented a detailed history of the Unit 20A moose population through 1978, while Boertje et al. (1996) presented a history through 1995.

Preferred moose habitat is composed of riparian willow, poorly drained meadows, shallow lakes, early successional forest, and subalpine shrub communities. Approximately 5040 mi^2 of the unit is suitable moose habitat (the area below 4000 feet in elevation exclusive of large lakes).

Moose numbers increased in Unit 20A during the 1950s and reached high densities in the early 1960s, perhaps 4–5 moose/mi^2. Reported annual moose harvests averaged 311 moose between 1963 and 1969 (McNay 1993). During 1969–1974, reported harvest increased to an average of 617 moose per year. Cow moose composed 34% of the annual harvest during 1963–1974.

Similar to numerous other ungulate populations in Alaska, the moose population declined beginning in the late 1960s and reached its lowest point in the mid 1970s. Beginning in 1975, seasons and harvests were dramatically reduced and taking of cows was prohibited. Between February 1976 and April 1982 the division reduced wolf numbers. During 1975–1978, mean annual reported moose harvest was 64 bulls.

During the 1976–1982 wolf reduction efforts in Unit 20A, the moose population increased rapidly and has increased or remained stable most years since 1982. During 1979–1982, reported harvests averaged 226 bulls per year (McNay 1993). During 1983–1993 the mean

[a] This unit report also includes data collected outside the reporting period at the discretion of the reporting biologist.

annual harvest increased to 358 bulls. A wolf control program to reduce predation on the declining Delta caribou herd began in October 1993, but was discontinued in December 1994. Division staff reduced wolf numbers by trapping and snaring, and this may have influenced moose population dynamics. Antlerless hunts were resumed in 1996, suspended in 1999, and again resumed in 2000, but harvests ($\bar{x}$ = 72.5 antlerless moose) accounted for only a small portion of the overall harvest. Reported harvest of bulls reached all-time highs in the late 1990s ($\bar{x}$ = 623 bulls, 1996–1999). As a result, seasons were shortened in 2000, and antler restrictions were imposed in 2002 to reduce harvests to sustainable levels.

Regulations have provided for a wide variety of hunting opportunities in Unit 20A. For example, the southwestern portion of the unit currently includes the Wood River Controlled Use Area (WRCUA; no motorized access except aircraft), the Ferry Trail Management Area (FTMA; motorized access, but antler restrictions since 1988), the Healy Lignite Management Area (HLMA; bowhunting only), the Yanert Controlled Use Area (YCUA; no motorized access except aircraft, antler restrictions since 1988), and the Nenana Controlled Use Area (NCUA; no airboats for hunting moose).

Approximately one-third of Unit 20A is military land, including 1003 mi^2 of Fort Wainwright Army property, 893 mi^2 of Fort Greely Army property, and 17 mi^2 of Clear Air Force Station property. A variety of access restrictions, both spatial and temporal, apply to portions of these military lands.

MANAGEMENT DIRECTION

MANAGEMENT GOALS

- Protect, maintain, and enhance the moose population and its habitat in concert with other components of the ecosystem.
- Provide the greatest sustained opportunity to participate in hunting moose.
- Provide an opportunity to view and photograph moose.

MANAGEMENT OBJECTIVES

- Manage for a November population of between 10,000 and 12,000 moose.
- Manage for a posthunting sex ratio of ≥30 bulls:100 cows overall and ≥20 bulls:100 cows in the Tanana Flats, Western Foothills, and Eastern Foothills areas.

METHODS

POPULATION STATUS AND TREND

2001 Population Estimation Survey

We surveyed 78 (50 high-density and 28 low-density; 455 mi^2) of 987 sample units (SU; 5747 mi^2) during 31 October–18 November. We used the Geostatistical Population Estimator method (GSPE; Ver Hoef 2001), a modification of the standard Gasaway et al. (1986)

technique. A simple random sample of SUs was selected from each stratum using Microsoft®Excel Windows®98 software. "Tanana Flats" and "Foothills" portions of Unit 20A, which were treated as separate geographic strata in 1996, 1997, and 1998 surveys, were combined after 1998.

The GSPE method does not yet employ a sightability correction factor (SCF), thus does not correct for moose not seen during the survey. Rather, the GSPE method employs greater search intensity, 8–10 min/mi^2 versus 4–6 min/mi^2 (Gasaway et al. 1986), resulting in a higher level of sightability. Preliminary work with the sightability of collared moose known to be in sample units indicates that a SCF of 1.1 to 1.15 is appropriate for most of Unit 20A GSPE surveys, but more work is needed.

Search intensity averaged 6.9 min/mi^2, slightly less than the recommended 8–10 min/mi^2. However, search intensity was not corrected for areas of nonmoose habitat (e.g., >4500 feet in elevation or large bodies of water) that were not searched. Therefore, actual search intensity was certainly greater and probably reached recommended levels. Survey conditions (Gasaway et al. 1986) with regard to snow (age and cover), light (intensity and type), and wind (strength and turbulence) were reported primarily as good (70%), with the remainder reported as excellent (18%) or poor (12%). Snow conditions tended to deteriorate as the survey period progressed. Turbulence was not a factor, although surveys were suspended several days due to high or turbulent winds.

2002 Population Estimation Survey

Population estimation surveys were not conducted in 2002 due to insufficient snow accumulation.

2003 Population Estimation Survey

We surveyed 112 (65 high-density and 47 low-density; 649 mi^2) of 987 SUs (5747 mi^2) during 21 November–11 December using the methods described above.

Search time per SU averaged 45 minutes. Adjusted search intensity (search time/estimated percentage of moose habitat in the SU/5.8 mi^2 per SU) averaged 9.0 min/mi^2. Survey conditions (Gasaway et al. 1986) with regard to snow (age and cover), light (intensity and type), and wind (strength and turbulence) were reported primarily as good (67%), with the remainder reported as excellent (25%), fair (4%), or unclassified (4%).

Twinning Surveys

Twinning rates in 2002 and 2003 were estimated from surveys conducted in traditional twinning survey trend count areas in the central Tanana Flats. Surveys consisted of roughly parallel transects flown at approximately ½-mile intervals at ≤500 feet above ground level in PA-18 or Scout aircraft by experienced contract pilots. All moose observed were classified as bull, yearling cow, adult cow without a calf, or adult cow with single, twin or triplet calves. Twinning rate surveys were flown on 24–25 May 2002 (7.1 hr) and 27–28 May 2003 (6.6 hr) during or within a few days after the median calving date (R. Boertje, ADF&G files). When the median calving date was unknown and <15% of the cows had calves, we terminated surveys, excluded the data, and flew a few days later. For statistical reasons we established,

a priori, a minimum sample size of 50 cows with calves. Twinning rate was calculated as the proportion of cows with twins or triplets from the sample of all cows with calves.

Browse Surveys

We conducted moose browse surveys in Unit 20A in spring 2003, sampling 20 sites in the eastern (n = 11) and southwestern (n = 9) portions of the unit. Sites were selected, a priori, from U.S. Geological Survey topographic maps based primarily on physiographic (i.e., valley bottom vs. side slope vs. ridgetop) and habitat (i.e., riparian vs. upland; shrubland vs. open forest vs. closed forest; wet vs. dry) features. We attempted to select a highly dispersed, representative sample of sites relative to the above physiographic and habitat parameters that also had a high proportion of preferred browse species (i.e., *Salix* spp., birch and aspen). Sampling of plant architecture (i.e., Broomed Index) at individual sites followed the methods of Seaton (2002).

HARVEST

We estimated annual harvest from mandatory harvest report cards. This included data from report cards from the general season hunt and from several drawing hunts, e.g., drawing hunts for bulls in the eastern portion of the WRCUA, antlerless moose in the central portion of Unit 20A, and calves unitwide. Reminder letters were sent to nonreporting general season hunters, and up to 2 letters were sent to permit holders who failed to report. We summarized data on hunter residency, hunter success, harvest chronology, and transport methods. When antler size of bulls was reported, we considered bulls with antler spreads <30 inches to be yearlings. Harvest data were summarized by regulatory year (RY), which begins 1 July and ends 30 June (e.g., RY02 = 1 Jul 2002–30 Jun 2003).

We estimated other mortality from Department of Public Safety records of collisions with motor vehicles and Alaska Railroad records of collisions with trains.

WEATHER

We evaluated weather (snowfall and temperature) using National Weather Service records and personal observations.

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Population Size

GSPE estimates of 11,205 (9636–12,774; 90% CI) moose in 1999, 10,557 (8657–12,457; 90% CI) in 2000, 11,511 (9784–13,238; 90% CI) in 2001, and 14,684 (12,801–16,566; 90% CI) in 2003 (Table 1) indicate that the Unit 20A moose population has increased since 1999. Applying a preliminary SCF of 1.12 results in population point estimates of 12,550 (1999), 11,824 (2000), 12,892 (2001), and 16,446 (2003). The 2003 corrected estimate yields a density of >3 moose/mi^2 (16,446 moose/5040 mi^2 of suitable moose habitat).

Dale (1998) reported that the Unit 20A moose population grew at an average annual finite growth rate of 1.027 between 1988 and 1996. Young (2002) reported that between 1996 and 2001 the population had likely stabilized. However, comparing the 1999 estimate of 7213 cows with the 2003 estimate of 9106 cows reveals an average annual finite growth rate of 1.066 during that period.

Population Composition

In 2001 we classified 887 moose and estimated 26 calves:100 cows and 26 bulls:100 cows (Table 1). In 2003 we classified 1483 moose and estimated 28 calves:100 cows and 32 bulls:100 cows. The relatively low calf:cow ratios observed in 2001 and 2003 were probably the result of alternating years of low parturition rates those years (R. Boertje, ADF&G files). Sex ratios declined from 39 bulls:100 cows in 1996 to 23 bulls:100 cows in 1999 and remained below the management objective of 30:100 through 2001 (Table 1). Bull:cow ratios of 26:100 in 2001 and 32:100 in 2003 suggest that the shorter bull moose season (beginning RY00) and unitwide antler restrictions (beginning RY02) were effective in improving the bull:cow ratio.

We met our objective of ≥20 bulls:cows in the Tanana Flats, Western Foothills, and Eastern Foothills portions of Unit 20A. In 2001 bull:cow ratios were similar in the Tanana Flats (26:100) and Western Foothills (22:100), but higher in the Eastern Foothills (40:100). In 2003 sex ratios were more similar across the Tanana Flats (32:100), Western Foothills (31:100), and Eastern Foothills (34:100).

In the southwestern portion of Unit 20A, where numerous trails provide motorized access, the bag limit has been 1 bull with spike-fork or 50-inch antlers (subsequently referred to as SF50) since RY88. This antler restriction was adopted in response to declining bull:cow ratios between RY84 (23–42 bulls:100 cows; Jennings 1986) and RY87 (13–27 bulls:100 cows; McNay 1989). Bull:cow ratios improved during the early 1990s, presumably because of the antler restriction. For example, bull:cow ratios exceeded the management objective for the Western Foothills of 20 bulls:100 cows in 1993 (31 bulls:100 cows in the Walker Dome trend area). However, since the mid 1990s, bull:cow ratios in the FTMA declined from an estimated 26:100 in 1994 to 9:100 in 2001. In addition, in the Western Tanana Flats, bull:cow ratios were at or below 20 bulls:100 cows in both 2000 (20:100) and 2001 (17:100). Unitwide antler restrictions that went into effect in RY02 appeared to improve bull:cow ratios in those areas (2003: FTMA = 24:100; Western Tanana Flats = 36:100).

Twinning Rates

Twinning rates remained poor at 9% to 10% in 2002 and 2003, but similar to the mean of 9% (range 3–18%) observed during 1994–2001 (Table 2). This is consistent with other measures of poor productivity observed in Unit 20A moose, such as low parturition rates, reproductive pauses, and delayed age of first reproduction. All these factors indicate the Unit 20A moose population is nutritionally stressed (Boertje et al. 1999) because of high moose densities and, presumably, declining habitat quality.

Distribution and Movements

Moose distribution varies widely across Unit 20A. Boertje et al. (2000) reported that a 2598-mi^2 study area in central Unit 20A contained about 50% of the moose habitat, but about 67% of the moose in November. For example, in 1996 he found 30% higher moose density in the study area compared to the total Unit 20A moose density. In addition, the moose population consists of nonmigratory and migratory subpopulations (Gasaway et al. 1983). From February to April many bull and cow moose migrate from the surrounding foothills (Alaska Range and Chena and Salcha River drainages) to calving areas on the Tanana Flats in Unit 20A. They remain there at least through June in most years and return to the foothills from July through October. Although we do not know what proportion of the moose migrate, Gasaway et al. (1983) estimated that the seasonal migrants probably increase the density of moose on the Tanana Flats 2- to 4-fold over the density of resident Unit 20A moose. R Boertje (ADF&G files) also estimated that in the 1807 mi^2 Tanana Flats portion of his central study area, calving and summer density were 1.7 to 2.0 times the November (1996) density.

MORTALITY

Harvest

Seasons and Bag Limits. Seasons and bag limits in Unit 20A during RY01 were as follows:

Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Unit 20A, the Ferry Trail Management Area and the Yanert Controlled Use Area		
RESIDENT HUNTERS: 1 bull with spike-fork antlers or 50-inch antlers or antlers with 4 or more brow tines on 1 side.	1 Sep–20 Sep (General hunt only)	
NONRESIDENT HUNTERS: 1 bull with 50-inch antlers or antlers with 4 or more brow tines on 1 side.		1 Sep–20 Sep
Unit 20A within the Nenana Controlled Use Area		
RESIDENT HUNTERS: 1 bull.	1 Sep–20 Sep (General hunt only)	
NONRESIDENT HUNTERS: 1 bull with 50-inch antlers or antlers with 4 or more brow tines on 1 side.		1 Sep–20 Sep

Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Remainder of Unit 20A		
1 moose per regulatory year only as follows:		
RESIDENT HUNTERS: 1 bull; or	1 Sep–20 Sep (General hunt only)	
1 antlerless moose by drawing permit only; up to 300 permits may be issued; or	1 Sep–25 Sep (General hunt only)	
1 bull by drawing permit only; by muzzleloading firearms only; up to 75 permits may be issued.	1 Nov–30 Nov (General hunt only)	
NONRESIDENT HUNTERS: 1 bull with 50-inch antlers or antlers with 4 or more brow tines on 1 side; or		1 Sep–20 Sep
1 antlerless moose by drawing permit only; up to 300 permits may be issued; or		1 Sep–25 Sep
1 bull with 50-inch antlers or antlers with 4 or more brow tines on 1 side by drawing permit only; by muzzleloading firearms only; up to 75 permits may be issued.		1 Nov–30 Nov

Seasons and bag limits in Unit 20A during RY02 were as follows:

Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Unit 20A, the Ferry Trail Management Area, Wood River Controlled Use Area, Healy–Lignite Management Area, and the Yanert Controlled Use Area.		
RESIDENT HUNTERS: 1 bull with spike-fork antlers or 50-inch antlers or antlers with 4 or more brow tines on 1 side; or	1 Sep–20 Sep (General hunt only)	

Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
1 antlerless moose by drawing permit only; up to 300 permits may be issued in Unit 20A; a recipient of a drawing permit is prohibited from taking an antlered bull moose in Unit 20A; or	1 Sep–25 Sep (General hunt only)	
1 calf moose by drawing permit only; up to 300 permits may be issued in Unit 20A; a recipient of a drawing permit is prohibited from taking an antlered bull moose in Unit 20A; or	1 Sep–25 Sep (General hunt only)	
1 bull with spike-fork antlers or 50-inch antlers or antlers with 4 or more brow tines on 1 side; by drawing permit only; by muzzleloading firearms only; up to 75 permits may be issued	1 Nov–30 Nov	
NONRESIDENT HUNTERS: 1 bull with 50-inch antlers or antlers with 4 or more brow tines on 1 side; or		1 Sep–20 Sep
1 bull with 50-inch antlers or antlers with 4 or more brow tines on 1 side; by drawing permit only; by muzzleloading firearms only; up to 75 permits may be issued		1 Nov–30 Nov
Unit 20A within the Nenana Controlled Use Area.		
RESIDENT HUNTERS: 1 bull with spike-fork antlers or 50-inch antlers or antlers with 3 or more brow tines on 1 side; or	1 Sep–20 Sep (General hunt only)	
1 antlerless moose by registration permit only during the season to be announced by emergency order; a recipient	1 Sep–25 Sep (General hunt only)	

Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
of a registration permit is prohibited from taking an antlered bull moose in Unit 20A; or		
1 calf moose by drawing permit only; up to 300 permits may be issued in Unit 20A; a recipient of a drawing permit is prohibited from taking an antlered bull moose in Unit 20A; or	1 Sep–25 Sep (General hunt only)	
NONRESIDENT HUNTERS: 1 bull with 50-inch antlers or antlers with 4 or more brow tines on 1 side.		1 Sep–20 Sep
Remainder of Unit 20A		
1 moose per regulatory year only as follows:		
RESIDENT HUNTERS: 1 bull with spike-fork antlers or 50-inch antlers or antlers with 3 or more brow tines on 1 side; or	1 Sep–20 Sep (General hunt only)	
1 antlerless moose by drawing permit only; up to 300 permits may be issued in Unit 20A; a recipient of a drawing permit is prohibited from taking an antlered bull moose in Unit 20A; or	1 Sep–25 Sep (General hunt only)	
1 calf moose by drawing permit only; up to 300 permits may be issued in Unit 20A; a recipient of a drawing permit is prohibited from taking an antlered bull moose in Unit 20A	1 Sep–25 Sep (General hunt only)	
NONRESIDENT HUNTERS: 1 bull with 50-inch antlers or antlers with 4 or more brow tines on 1 side		1 Sep–20 Sep

Alaska Board of Game Actions and Emergency Orders. In RY91 the bag limit for the FTMA and YCUA was 1 bull moose with spike-fork or 50-inch antlers or antlers with 3 or more brow tines on 1 side (SF50/3). During RY92–RY95 the bag limit for the FTMA and YCUA was 1 bull moose with spike-fork or 50-inch antlers or antlers with 4 or more brow tines on one side (SF50/4). During RY96–RY99 the bag limit was changed back to 1 bull moose with SF50/3. Then in RY00 the Board of Game again increased the brow tine requirement to SF50/4 in these areas. At that time, the board also restricted the bag limit for nonresident hunters in all of Unit 20A to 1 bull moose with 50-inch antlers or antlers with 4 or more brow tines on 1 side. Those bag limits remained in effect through the RY02 hunting season. The board took action to restrict resident bag limits for moose throughout Unit 20A in RY02. The resident bag limit for the FTMA, HLMA, WRCUA, and YCUA was 1 bull moose with SF50/4, and for the remainder of Unit 20A, 1 bull moose with SF50/3. The nonresident bag limit was unaffected and remained 1 bull moose with 50-inch antlers or antlers with 4 or more brow tines on 1 side.

The board adopted 3 antlerless moose hunts by drawing permit (up to 300 permits) in RY96. Two (DM760 and DM762) occurred on the northcentral Tanana Flats near Fairbanks where moose densities were high. The third antlerless hunt (DM764) occurred in the eastern portion of the WRCUA. The antlerless hunts were suspended in RY99 because of an agreement with local advisory committees that cows would only be hunted when the population was increasing, and in 1999 the population was believed to be stable. These 3 hunts were resumed in RY00 when advisory committees and the board agreed to authorize the hunts as long as the moose population was stable or increasing. In RY02, the board also authorized an antlerless hunt by registration permit, 1–25 September, for the Unit 20A portion of the NCUA (i.e., the Western Tanana Flats) and up to 300 drawing permits for calf moose for the period 1–25 September. The calf hunt was experimental and was revisited and eliminated by the board in 2004. Finally, in RY02 the board authorized that recipients of antlerless drawing registration permits and calf drawing permits be prohibited that year from hunting for antlered bull moose in Unit 20A.

The board made no changes during the past 2 reporting periods to muzzleloader permit hunt DM766 created in RY96. This bulls-only hunt allows the department to issue up to 75 permits for hunters using muzzleloaders in a portion of the WRCUA during November. Seventy-five permits were issued in RY99, but none were issued RY00–RY02 because of an agreement with local advisory committees not to issue permits until bull:cow ratios recovered.

The board created the NCUA in portions of Units 20A and 20C in RY96, which prohibited the use of airboats for hunting or transporting moose hunters or their gear during 1–25 September. The NCUA was modified in RY98 to allow the use of airboats for hunting moose within the main channels of the Teklanika, Toklat, and Nenana Rivers, and at the public boat launch in Nenana.

The board modified the common boundary between the FTMA and WRCUA from the Totatlanika River to Tatlanika Creek in RY98. The boundary was changed back to the Totatlanika River in RY00. Although there was action at the spring 2002 board meeting to move the boundary back again to Tatlanika Creek, the proposal failed.

Intensive Management (IM) deliberations for Unit 20 were postponed during the spring 2000 meeting until November, at which time the board adopted IM population (10,000–12,000 moose) and harvest (500–720 moose) objectives for Unit 20A.

Alaska Board of Game Actions, March 2004 — The board took the following actions for moose in Unit 20A:

- Extended the general bull season to 1–25 September;
- Established a registration permit hunt for antlerless moose from 1 September to 10 December in all Unit 20A and eliminated the antlerless and calf moose drawing hunts;
- Eliminated the regulation prohibiting recipients of antlerless drawing permits, calf drawing permits, and registration permits from hunting that year for antlered bull moose in Unit 20A;
- Eliminated the NCUA; and
- Increased the Unit 20A IM Harvest Objective to 1400–1600 moose.

Hunter Harvest. Reported harvest of bull moose during the general season increased 66% between RY90–RY91 ($\bar{x}$ = 376 bulls) and RY96–RY97 ($\bar{x}$ = 613 bulls), and then remained relatively stable through RY99 (Table 3). Liberalizing the general season from 20 to 25 days in Unit 20A in RY95 likely contributed to the increased harvest. Average annual reported harvest RY00–RY01 declined to 540 bulls after the general season was reduced by 5 days (1–20 Sep) and unitwide antler restrictions were adopted for nonresident hunters. Reported harvest declined even further to 363 bulls after unitwide antler restrictions were imposed on resident hunters in RY02.

Permit Hunts. Hunter participation and harvest was lower than expected for antlerless drawing permit hunts through RY01 (Table 4). This may partly be explained by many permittees choosing to take bull moose rather than filling their antlerless permit. To increase participation and harvest in permit hunts, the board adopted a regulation prohibiting recipients of drawing and registration permits for antlerless and calf moose from taking an antlered bull moose in Unit 20A. As a result, reported harvests of antlerless moose increased from a mean of 68 (range 61–76; RY96–RY98 and RY00–RY01) to 94 in 2002. Likewise, success rates (reported harvest/number permits issued) jumped from 23% (68/300) RY96–RY98 and RY00–RY01 to 46% (94/205) in RY02.

Hunter Success and Residency. Hunter success rates during the general hunting season tended to be higher in Unit 20A (Table 5) than surrounding subunits (i.e., 20B, 20C, 20F and 25C; Selinger 2000; Young 2000*a*,*b*). Success rates reached their highest level in 10 years in RY99 (42%). In RY00 and RY01, success rates were lower than those reported for the previous 5 regulatory years (RY95–RY99). This was probably a function of reduced season length; success rates were higher in years with a 25-day season (RY95–RY99) than years with a 20-day season (RY90–RY94 and RY00–RY01). Success rates dropped to 30% after unitwide

antler restrictions went into effect in RY02. Nonresidents had higher success rates than residents. For example, in RY02 the most comparable year in terms of bag limits between nonresidents (SF50/4 unitwide) and residents (SF50/4 in SW mountains, SF50/3 remainder of Unit 20A), 55% of the nonresident hunters were successful, compared to 26% for resident hunters.

The number of hunters who reported hunting moose during the general season in Unit 20A increased during the early to mid 1990s, but then remained relatively stable during RY96–RY01. A 40% increase between RY94 (n = 1166) and RY96 (n = 1636) was likely due, at least in part, to the liberalization of the general moose season in RY95 from 20 to 25 days. However, a reduction in season length from 25 to 20 days beginning in RY00 did not result in a commensurate reduction in the number of moose hunters. However, a sharp reduction in the number of hunters in RY02 (n = 1181) was probably because of unitwide antler restrictions being imposed on resident hunters.

Harvest Chronology. Moose harvest in Unit 20A has traditionally been well distributed throughout the season (Table 6). However, when the general season was shortened to 20 days in RY00–RY02, fewer bulls were reported taken 6–10 Sep ($\bar{x}$ = 19%) than 1–5 Sep ($\bar{x}$ = 24%), 11–15 Sep ($\bar{x}$ = 27%) or 16–20 Sep ($\bar{x}$ = 27%).

Transport Methods. During the last 10 regulatory years, approximately two-thirds of the successful moose hunters used airplanes or boats (including airboats; Table 7). Hunting by horseback was popular in the YCUA and the southern portion of the WRCUA. Three- and 4-wheeler use increased during the early to mid 1990s, but appears to have stabilized. The FTMA continued to be a popular place for hunters using 3- and 4-wheelers. In addition, hunters increasingly used boats to transport these vehicles to the Tanana Flats.

Airboat use remains controversial. Since RY97, airboats have been distinguished as a transportation category on harvest report cards. The percentage of successful moose hunters in Unit 20A that used airboats increased slightly during the RY01–RY02 reporting period ($\bar{x}$ = 7.5%) compared to the RY97–RY00 reporting period ($\bar{x}$ = 5.7%, Table 6). That trend will probably continue as a result of the board eliminating the NCUA (restricted use of airboats for moose hunting in the western Tanana Flats portion of Unit 20A) beginning in RY04.

Other Mortality

A study of moose mortality began in 1996, and a progress report is available (Boertje et al. 1999). The number of moose killed in accidents with motor vehicles and trains has been substantial in some years (Dale 1998), but was relatively low during RY01–RY02 (Table 3). This may be the result of below average snowfall (long-term mean for Fairbanks = 68 in) during winters 2001–2002 (48.8 in) and 2002–2003 (41.4 in).

WEATHER

Unusual weather may have influenced moose population dynamics during RY90–RY02. Winter 1990–1991 had the highest snowfall on record in Fairbanks (147.3 in) and was closely followed by 1992–1993 (139.1 in). These record snowfalls are over twice the long-term average (68 in). In contrast, winters 1997–1998 (46.0 in), 1998–1999 (31.0 in), 2000–2001

(56.6 in), 2001–2002 (48.8 in), and 2002–2003 (41.4 in) received less than normal accumulations of snow ($\bar{x}$ = 44.8 in). An example of extreme deviation from the norm in terms of snow accumulation occurred in late winter 2002–2003 when a large portion of Unit 20A was snow free due to low snow accumulations and unseasonably warm temperatures.

Summer 1992 was probably the shortest on record. It was bracketed with snowfall in mid May and in September (24 inches of snowfall, 3 times the previous record, and cold temperatures, 13 degrees colder than previous record). Conversely, 1993 was probably the longest summer on record, with an early spring leaf-out, warm summer temperatures, and a late fall.

More recently, summer 2000 was short, had relatively few snow-free days, and was relatively cool with the lowest number of growing degree-days (n = 754) since 1965 (Boertje and Kellie 2003). By comparison, the growing degree-days index for summers 1996 through 1999 averaged 845.

HABITAT

There has been considerable discussion in recent years about the potential for Unit 20A to support many more moose, given the poor reproductive condition. We remain concerned about the population exceeding the habitat capability and becoming vulnerable to severe weather patterns. Already we have documented that this population has the lowest productivity of studied moose populations in North America (Boertje et al. 2000). Therefore, a higher moose density is not desirable until habitat improves. Two large wildfires (114,000-acre Survey Line Burn and 85,000-acre Fish Creek Burn) occurred on the Tanana Flats during summer 2001, but potential benefits to the moose population will probably not be realized for many years. Mortality research implemented in 1996 is evaluating many factors influencing the status of the moose population relative to habitat, predators, and sustainable harvest.

NONREGULATORY PROBLEMS/ISSUES

An electric intertie constructed between Healy and Fairbanks that bisects important moose habitat in western Unit 20A will probably affect moose in 2 ways. First, the intertie corridor may improve access, and changes in regulations to prevent local overharvest of bulls may be necessary. More importantly, increased fire suppression near the corridor may adversely affect habitat capability for moose over time.

CONCLUSIONS AND RECOMMENDATIONS

Population estimates indicate the Unit 20A moose population increased between 1999 and 2003 and has exceeded the upper limit of the population objective. Estimates indicate the adult (≥1 year of age) cow population, our most reliable estimate of population growth, increased at a rate of 6–7% annually. Low twinning rates, 0% yearling pregnancy rates, delayed age of first reproduction, and reproductive pauses are all indicative of a relatively unproductive moose population. Current research indicates that moose production in

Unit 20A is reduced because of high moose densities and, presumably, declining habitat quality. Therefore, I recommend we liberalize (i.e., convert from drawing to registration permit hunts, lengthen the season, and expand the hunt area) antlerless moose hunts to increase harvest to 600 antlerless moose in RY04. Harvest goals for antlerless moose in RY05 should be reevaluated based on RY04 harvest levels and 2004 moose population estimates. My objective in the absence of large, landscape-scale improvements in habitat is to reduce the moose population to within the IM population objective of 10,000–12,000 moose. Antlerless (cow and calf) moose harvest should continue to be evaluated as a tool to prevent an overabundance of moose that are vulnerable to the synergistic effects of adverse weather and increased predation. In addition, it is important to improve habitat quality and determine the status of the Unit 20A moose population relative to nutrient and climate limitations, and increasing predator numbers (Boertje et al. 1996).

We met our management objectives of 20 bulls:100 cows in the Tanana Flats, Western Foothills and Eastern Foothills and 30 bulls:100 cows unitwide. Therefore, I recommend extending the season 5 days (1–25 Sep), but retaining unitwide antler restrictions for both resident and nonresident hunters. In addition, I recommend a harvest rate for bulls of approximately 15% of the prehunt bull population or 450–550 bulls in RY04 and RY05. We should continue to closely monitor bull:cow ratios both at unitwide and lesser spatial scales (e.g., management area, controlled use area, and subareas) to monitor the effects of current regulatory changes on bull:cow ratios.

We met the harvest objective of 500–720 moose in RY01, but not in RY02. To meet the current harvest objective of 1400–1600 moose annually, it will be necessary to harvest calves at a relatively high rate (~10%). Once the population is reduced below 12,000 moose, I recommend a selective harvest strategy (i.e., antler restricted bull hunts, cow hunts, and calf hunts) with a harvest ratio of approximately 60 bulls:20 cows:20 calves to maximize yield.

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TABLE 1 Unit 20A aerial moose fall composition counts and estimated population size, 1990–2003

Calendar year	Bulls:100 Cows	Yearlings: 100 Cows	Calves:100 Cows	Percent calves	Adults	Moose observed	Moose/mi^2	Estimated population size (90% CI)
1990[a]	23, 24, 26	15	48	27	584	292, 180, 158	2.0	10,100
1991[b]	22, 32	15	34	21	1954	949, 1531	2.2	11,100
1992[a]	28, 31, 36	14	36	21	274	107, 105, 137	2.2	11,300
1993[b]	29, 30	19	38	23	1340	852, 883	2.4	11,900
1994[c]	35	23	46	25	1038	1391	2.6	13,300
1995[d]	--	--	--	28	--	575	--	--
1996	39	24	42	23	2578	3343	2.3[e]	11,532 (± 13%)
1997	33	28	34	21	816	1037	2.6[e]	12,935 (± 27%)
1998	31	18	31	18	1035	1268	2.2[e]	11,144 (± 19 %)
1999	23	13	33	21	760	965	2.2[f]	11,205 (± 14%) [f]
2000	23	10	33	21	1089	1377	2.1[f]	10,557 (± 18 %) [f]
2001	26	18	26	17	737	887	2.3[f]	11,511 (± 15%) [f]
2002[g]								
2003	32	22	28	18	1212	1483	2.9[f]	14684 (± 13%) [f]

[a] Windy, Walker Dome, and Japan Hills trend areas, respectively.
[b] Central Tanana Flats and Western Foothills, respectively.
[c] Central Tanana Flats and Western Foothills combined.
[d] Lack of snow prevented early winter surveys.
[e] Corrected for sightability (SCF) =1.178 for 1996 and 1.15 for 1997–1998.
[f] Geo-statistical Population Estimation method does not yet incorporate a SCF, but preliminary work suggests a SCF of 1.1 to 1.15 will be appropriate for Unit 20A (see methods).
[g] Surveys were not conducted due to lack of snow.

TABLE 2 Unit 20A Tanana Flats moose twinning rates from transect surveys, 1987–2003

Calendar year	Date	Cows			% Twins[a]
		w/Single calf	w/Twins	Total	
1987	20, 22, 23 May	43	5	48	10
1988	21, 23 May	52	8	60	13
1989	20, 21, 24 May[b]	43	8	51	16
1990	24 May	25	7	32	22
1991	20, 22 May	19	5	24	21
1992[c]					
1993	21-24, 28 ,29 May	50	0	50	0
1994	22 May	42	9	51	18
1995	21-22 May	47	3	50	6
1996	24, 26 May	66	12	78	15
1997	21, 25 May	48	4	52	8
1998	26, 30 May	51	4	55	7
1999	25–26 May	62	2	64	3
2000[d]	14 May–9 June	27	3	30	10
2001[d]	14 May–6 June	30	1	31	3
2002	24–25 May	52	6	58	10
2003	27–28 May	53	5	58	9

[a] Percentage of cows with calves that had twins.

[b] Includes data from surveys when paired helicopter/fixed-wing observations were made (24 May) and when only fixed-wing observations were made (20–21 May).

[c] No calving data available.

[d] No transect surveys were flown in 2000 and 2001. These data were derived from radiocollared cows ≥ 5 years old plus 4 3- or 4-year-old moose with single calves to simulate the population structure observed in transect surveys. Radiocollared 3- and 4-year-old cows did not produce viable twins during 1996–2003 (R. Boertje, ADF&G files).

TABLE 3 Estimate of Unit 20A moose harvest[a] and accidental death, regulatory years 1990–1991 through 2002–2003

Regulatory year	Harvest by hunters							Accidental death			Total
	Reported				Estimated						
	M	F	Unk	Total	Unreported[b]	Illegal/Other[c]	Total	Road[d]	Train[e]	Total	
1990–1991	370	0	0	370	65		65				435
1991–1992	382	0	0	382	68		68				450
1992–1993	246	0	0	246	44		44				290
1993–1994	386	0	0	386	68		68				454
1994–1995	399	0	0	399	71		71				470
1995–1996	526	0	0	526	93		93				619
1996–1997	617	61	0	678	120		120				798
1997–1998	629	68	2	699	124	11	135	2	17[e]	19	853
1998–1999	613	74	4	691	122	3	125	3	15[e]	18	834
1999–2000	660	1	16	677	120	5	125	3	11[e]	14	816
2000–2001	539	70	4	613	109	9	118	2	34[e]	36	767
2001–2002	541	70	4	615	109	62	171	3	4[f]	7	793
2002–2003	363	115	1	479	85	61	146	7	6[f]	13	638

[a] Includes general and permit hunt harvest.
[b] Based on 17.7% unreported harvest (including wounding loss) estimated by Gasaway et al. (1992).
[c] Includes illegal, DLP, dispatched, potlatch, stickdance, and other reported deaths.
[d] Documented kills; actual number killed by vehicles is certainly greater.
[e] Confirmed dead between Alaska Railroad (ARR) mileposts 327.0 and 411.7 (ARR mileposts 327.0 through 369.9 are located in Unit 20C near the Unit 20A border); "Missing" moose (moose hit but not recovered) are not included. Data provided by the Alaska Railroad.
[f] Confirmed dead between ARR mileposts 371.0 and 411.7; "Missing" moose (moose hit but not recovered) are not included. Data provided by the Alaska Railroad.

TABLE 4 Unit 20A moose harvest data by permit hunt, regulatory years 1996–1997 through 2002–2003

Permit hunt	Regulatory year	Permits issued	Did not hunt	(%)	Unsuccessful hunters	(%)	Successful hunters	(%)	Male	(%)	Female	(%)	Unk	(%)	Harvest
DM750	2002–2003	65	39	(60)	20	(77)	6	(23)	2	(33)	4	(67)	0	(0)	6
DM752	2002–2003	65	44	(68)	13	(62)	8	(38)	3	(38)	5	(63)	0	(0)	8
DM754	2002–2003	37	23	(62)	9	(64)	5	(36)	2	(40)	3	(60)	0	(0)	5
DM755	2002–2003	30	6	(20)	16	(67)	8	(33)	5	(63)	3	(38)	0	(0)	8
DM756	2002–2003	5	1	(20)	2	(50)	2	(50)	0	(0)	2	(100)	0	(0)	2
DM757	2002–2003	20	10	(50)	9	(90	1	(10)	1	(100)	0	(0)	0	(0)	1
DM758	2002–2003	33	27	(82)	5	(83)	1	(17)	0	(0)	1	(100)	0	(0)	1
DM759	2002–2003	20	16	(80)	3	(75)	1	(25)	1	(100)	0	(0)	0	(0)	1
Total DM750–DM759	2002–2003	275	166	(60)	77	(71)	32	(29)	14	(44)	18	(56)	0	(0)	32
RM767	2002–2003	30	3	(10)	12	(44)	15	(56)	0	(0)	15	(100)	0	(0)	15
DM760	1997–1998	75	17	(23)	32	(55)	26	(45)	0	(0)	26	(100)	0	(0)	26
	1998–1999	75	13	(17)	32	(52)	30	(48)	0	(0)	30	(100)	0	(0)	30
	1999–2000	0	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0
	2000–2001	75	14	(19)	32	(52)	29	(48)	1	(3)	28	(97)	0	(0)	29
	2001–2002	75	22	(29)	25	(47)	28	(53)	0	(0)	28	(100)	0	(0)	28
	2002–2003	50	4	(8)	13	(28)	33	(72)	0	(0)	33	(100)	0	(0)	33
DM762	1997–1998	75	23	(31)	24	(46)	28	(54)	4	(14)	24	(86)	0	(0)	28
	1998–1999	75	22	(29)	23	(43)	30	(57)	3	(10)	27	(90)	0	(0)	30
	1999–2000	0	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0
	2000–2001	75	18	(24)	27	(47)	30	(53)	2	(7)	28	(93)	0	(0)	30
	2001–2002	75	22	(29)	26	(49)	27	(51)	3	(11)	24	(89)	0	(0)	27
	2002–2003	50	14	(28)	9	(25)	27	(75)	0	(0)	27	(100)	0	(0)	27
DM764	1997–1998	150	107	(71)	34	(79)	9	(21)	1	(11)	8	(89)	0	(0)	9
	1998–1999	150	87	(58)	54	(86)	9	(14)	0	(0)	9	(100)	0	(0)	9
	1999–2000	0	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0

Permit hunt	Regulatory year	Permits issued	Did not hunt	(%)	Unsuccessful hunters	(%)	Successful hunters	(%)	Male	(%)	Female	(%)	Unk	(%)	Harvest
	2000–2001	150	100	(67)	37	(74)	13	(26)	1	(8)	12	(92)	0	(0)	13
	2001–2002	150	96	(64)	33	(61)	21	(39)	2	(10)	18	(86)	1	(5)	21
	2002–2003	75	36	(48)	20	(51)	19	(49)	0	(0)	19	(100)	0	(0)	19
Total RM767–DM764	1997–1998	300	147	(49)	90	(59)	63	(41)	5	(8)	58	(92)	0	(0)	63
	1998–1999	300	122	(41)	109	(61)	69	(39)	3	(4)	66	(96)	0	(0)	69
	1999–2000	0	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0
	2000–2001	300	132	(44)	96	(57)	72	(43)	4	(6)	68	(94)	0	(0)	72
	2001–2002	300	141	(47)	84	(53)	75	(47)	5	(7)	70	(92)	1	(1)	76
	2002–2003	205	57	(28)	54	(36)	94	(64)	0	(0)	94	(100)	0	(0)	94
DM766	1997–1998	75	43	(57)	18	(56)	14	(44)	14	(100)	0	(0)	0	(0)	14
	1998–1999	75	39	(52)	25	(69)	11	(31)	11	(100)	0	(0)	0	(0)	11
	1999–2000	75	32	(43)	23	(54)	20	(46)	20	(100)	0	(0)	0	(0)	20
	2000–2001	0	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0
	2001–2002	0	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0
	2002–2003	0	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0
Totals for all permit hunts	1997–1998	375	190	(51)	108	(58)	77	(42)	19	(25)	58	(75)	0	(0)	77
	1998–1999	375	161	(43)	134	(63)	80	(37)	14	(18)	66	(83)	0	(0)	80
	1999–2000	75	32	(43)	23	(53)	20	(47)	20	(100)	0	(0)	0	(0)	20
	2000–2001	300	132	(44)	96	(57)	72	(43)	4	(6)	68	(94)	0	(0)	72
	2001–2002	300	141	(47)	84	(53)	75	(47)	5	(7)	70	(92)	1	(1)	76
	2002–2003	480	223	(46)	131	(51)	126	(49)	14	(11)	112	(89)	0	(0)	126

TABLE 5 Unit 20A moose hunter[a] residency and success, regulatory years 1990–1991 through 2002–2003

Regulatory year	Successful						Unsuccessful						Total hunters
	Local[b] resident	Nonlocal resident	Nonresident	Unk	Total	(%)	Local[b] resident	Nonlocal resident	Nonresident	Unk	Total	(%)	
1990–1991	257	43	61	9	370	(31)	651	122	52	15	840	(69)	1210
1991–1992	264	62	48	8	382	(33)	566	148	48	10	772	(67)	1154
1992–1993	150	51	32	13	246	(25)	549	113	59	15	736	(75)	982
1993–1994	281	54	39	12	386	(34)	571	108	32	24	735	(66)	1121
1994–1995	270	67	45	17	399	(34)	605	103	43	16	767	(66)	1166
1995–1996	390	68	64	4	526	(38)	709	107	37	8	861	(62)	1387
1996–1997	427	102	73	5	607	(37)	830	134	61	4	1029	(63)	1636
1997–1998	406	110	98	5	619	(39)	738	163	65	10	976	(61)	1595
1998–1999	367	131	108	2	608	(37)	816	158	64	6	1044	(63)	1652
1999–2000	369	153	129	6	657	(42)	660	180	67	7	914	(58)	1571
2000–2001	326	138	73	4	541	(34)	713	213	115	2	1043	(66)	1584
2001–2002	350	131	56	2	539	(35)	705	219	81	7	1012	(65)	1551
2002–2003	190	77	85	1	353	(30)	567	190	70	1	828	(70)	1181

[a] Excludes hunters in permit hunts.
[b] Residents of Unit 20.

TABLE 6 Unit 20A moose harvest[a] chronology percent by month/day, regulatory years 1990–1991 through 2002–2003

Regulatory year	Harvest chronology percent by month/day						
	9/1–9/5	9/6–9/10	9/11–9/15	9/16–9/20	9/21–9/25	Unk/Other	*n*
1990–1991	27	12	27	29	1	3	370
1991–1992	24	19	28	25	0	3	382
1992–1993	45	24	13	16	0	2	246
1993–1994	34	19	25	17	1	4	386
1994–1995	27	20	23	25	0	5	382
1995–1996	19	17	21	22	15	4	526
1996–1997	26	15	19	22	14	4	607
1997–1998	24	15	17	22	18	4	619
1998–1999	22	15	17	24	19	3	608
1999–2000	20	15	25	22	15	2	657
2000–2001	26	18	25	27	0	3	541
2001–2002	24	21	24	28	0	3	539
2002–2003	22	18	31	26	0	2	353

[a] Excludes permit hunt harvest.

TABLE 7 Unit 20A moose harvest[a] percent by transport method, regulatory years 1990–1991 through 2002–2003

Regulatory year	Harvest percent by transport method									*n*
	Airplane	Horse	Boat	3- or 4-wheeler	Snowmachine	Other ORV	Highway vehicle	Airboat	Unknown	
1990–1991	37	6	31	9	0	9	4		3	370
1991–1992	34	5	29	14	0	10	5		3	382
1992–1993	33	4	27	16	2	10	7		2	246
1993–1994	34	2	37	12	0	6	7		2	386
1994–1995	29	3	33	22	0	8	5		0	399
1995–1996	30	4	35	17	0	7	4		2	526
1996–1997	28	3	32	20	0	10	4		3	607
1997–1998	32	4	22	23	0	5	6	5	3	619
1998–1999	37	3	19	22	0	7	4	7	1	608
1999–2000	36	5	18	20	0	11	4	5	1	660
2000–2001	37	5	19	19	0	10	3	5	1	541
2001–2002	34	5	19	20	0	10	3	7	1	539
2002–2003	36	5	14	23	0	8	3	8	2	353

[a] Excludes permit hunt harvest.

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MOOSE MANAGEMENT REPORT

From: 1 July 2001
To: 30 June 2003[a]

LOCATION

GAME MANAGEMENT UNIT: 20B (9114 mi^2)

GEOGRAPHIC DESCRIPTION: Drainages into the north bank of the Tanana River between Delta Creek and Manley Hot Springs

BACKGROUND

Moose numbers increased in Unit 20B throughout the 1950s and early 1960s after extensive wildfires improved moose habitat and federal predator reduction programs reduced wolf predation on moose (McNay 1993). Moose numbers declined following severe winters in 1965, 1970, 1971, and 1974. Increasing wolf predation and liberal either-sex hunting seasons contributed to the moose population decline. By 1976 moose densities were low, and the hunting season had been reduced to 10 days in most of Unit 20B. Moose populations again increased following wolf reduction programs conducted from 1980 to 1986. Hunting seasons were extended from 10 days in 1981 and 1982 to 20 days during 1983 through 1987. Reported harvests increased to approximately 300 bulls per year during 1983 through 1986. Harvests increased further from nearly 400 bulls in 1987 and 1988 to more than 700 bulls in 1998 and 2002, despite a 5-day reduction in the season.

Demand for moose hunting opportunities is high in Unit 20B. Extensive road systems and trails provide overland access, and numerous waterways such as the Tolovana, Tatalina, Chatanika, Goldstream, Salcha, and Chena Rivers provide boat access.

There were 2 permit moose hunts in Unit 20B during this reporting period, 1 in the Minto Flats Management Area (MFMA) and 1 in the Fairbanks Management Area (FMA). The MFMA was established in 1979 to restrict harvest in a low-density moose population. In 1988 the Alaska Legislature established the Minto Flats State Game Refuge to ensure the protection and enhancement of habitat and the conservation of fish and wildlife; and to guarantee the continuation of hunting, fishing, trapping, and other compatible public uses within approximately 900 mi^2 of the Minto Flats area.

[a] This unit report also includes data collected after the reporting period ended at the discretion of the reporting biologist.

The FMA was established in 1983 to provide moose hunting opportunities around the Fairbanks urban area by bow and arrow only. This area was closed to hunting in the late 1970s and early 1980s to prevent excessive harvest. Boundaries of the FMA changed numerous times, and the most recent changes went into effect in July 2002. The FMA currently encompasses about 300 mi^2, of which about 50 mi^2 has a relatively dense human population. Even though harvest is generally low, this permit hunt is popular.

For management purposes, Unit 20B is divided into 3 geographic zones: Unit 20B West (2942 mi^2), including the Minto Flats, Tatalina Creek drainage, Tolovana River drainage, and areas west; Unit 20B East (2425 mi^2) including the Little Salcha and Salcha River drainages; and Unit 20B Central (3829 mi^2), the remainder. Game management unit boundaries changed in 1981, increasing the size of Unit 20B and creating Unit 25C. Prior to 1981, the eastern and western portions of present-day Unit 20B and all of Unit 25C were considered part of Unit 20C. In 1993 the Unit 20B Central boundary was shifted westward. During regulatory year (RY) 2000, which begins 1 July and ends 30 June (e.g., RY00 = 1 Jul 2000–30 Jun 2001), Unit 20B West and Unit 20B Central boundaries were modified to coincide with Uniform Coding Unit (UCU) boundaries. As a result, the area of Unit 20B West decreased by approximately 1000 mi^2 and Unit 20B Central increased by that same amount.

MANAGEMENT DIRECTION

MANAGEMENT GOALS

- Protect, maintain, and enhance the moose population and its habitat in concert with other components of the ecosystem.
- Provide for continued subsistence use of moose by Alaska residents who have customarily and traditionally used the population.
- Provide the greatest sustained opportunity to participate in hunting moose.
- Provide an opportunity to view and photograph moose.
- Protect human life and property in human–moose interactions.

MANAGEMENT OBJECTIVE

- Manage for a posthunting sex ratio of ≥30 bulls:100 cows unitwide and ≥20 bulls:100 cows in each count area (i.e., Unit 20B East, Unit 20B Central, Unit 20B West, and MFMA).

METHODS

POPULATION STATUS AND TREND

2001 Population Estimation Survey

We surveyed 138 (54 low and 84 high density; 780 mi^2) of 1628 sample units (SU; 9196 mi^2) in Unit 20B during 6–26 November. We used the Geostatistical Population Estimator method

(GSPE; Ver Hoef 2001), a modification of the standard Gasaway et al. (1986) technique. A simple random sample of SUs was selected from each stratum using Microsoft®Excel for Windows®98 software. Previous analyses suggest survey effort and the precision of population estimates are optimized when the survey effort includes approximately 40% low density and 60% high-density sample units.

The GSPE method does not yet employ a sightability correction factor (SCF), so does not correct for moose not seen during the survey. Rather, the GSPE method employs greater search intensity of 8–10 min/mi^2 vs. 4–6 min/mi^2 (Gasaway et al. 1986), resulting in a higher level of sightability.

Preliminary work on sightability of collared moose indicates that a SCF of about 1.15 will eventually be applied to GSPE estimates in Unit 20B. Search intensity averaged 7.8 min/mi^2, slightly less than the recommended 8–10 min/mi^2. Survey conditions with regard to snow (age and cover), light (intensity and type), and wind (strength and turbulence) were reported primarily as fair (34%) and good (46%) with the remainder reported as excellent (13%) or poor (7%). Snow conditions tended to deteriorate as the survey period progressed. Turbulence was not a factor, although surveys were suspended several days due to high or turbulent winds.

2002 Population Estimation Survey

Surveys were not conducted due to insufficient snow accumulation in November.

Twinning Rate Surveys

Twinning rates were estimated from surveys conducted in traditional twinning survey trend count areas on Minto Flats. Surveys consisted of roughly parallel transects flown at approximately ½-mile intervals at ≤500 feet AGL in PA-18 or Scout aircraft by experienced contract pilots. All moose observed were classified as bull, yearling cow, adult cow without a calf, or adult cow with single, twin or triplet calves. Twinning rate surveys were flown for 4.8 hours on 29 May 2002 and 5.7 hours on 29 May 2003. In past years, we terminated surveys and excluded the data if <15% of the cows had calves. For statistical reasons, we established, a priori, a minimum sample size of 50 cows with calves. Twinning rate was calculated as the proportion of cows with twins or triplets from the sample of all cows with calves.

Browse Surveys

We conducted moose browse surveys in Unit 20B (MFMA) in spring 2003. We sampled 9 sites in the MFMA. Sites were selected, a priori, from U.S. Geological Survey topographic maps based primarily on physiographic (valley bottom vs. side slope vs. ridgetop) and habitat (riparian vs. upland; shrubland vs. open forest vs. closed forest; wet vs. dry) features. We attempted to select a highly dispersed, representative sample of sites relative to the above physiographic and habitat parameters that also had a high proportion of preferred browse species (i.e., *Salix* spp., birch and aspen). Sampling of plant architecture (i.e., Broomed Index) at individual sites followed the methods of Seaton (2002).

MORTALITY

We estimated harvest based on mandatory harvest report cards. This included data from report cards from the general season, the FMA drawing hunt, and the MFMA Tier II permit hunt. Reminder letters were sent to nonreporting general season hunters, and up to 2 letters were sent to permit holders who failed to report. When antler size of bulls was reported, we considered bulls with antler spreads of <30 inches to be yearlings. Harvest data were summarized by regulatory year.

We estimated accidental mortality from Department of Public Safety records of collisions with motor vehicles and Alaska Railroad records of collisions with trains.

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Population Size

The 2001 population estimate for Unit 20B was 10,261 moose (8517–12,005; 90% CI) or about 1.1 moose/mi^2. However, because snow conditions for surveys were marginal, the estimate may have been low. In spite of this, it is not likely we met the Intensive Management population objective of 12,000–15,000 moose established by the Board of Game for Unit 20B.

Prior to 2001 a unitwide population estimate had not been conducted since 1990 (McNay 1993). The population at that time was estimated at 9800 moose or about 1.1 moose/mi^2. Error bounds could not be calculated for that estimate because it included extrapolation; thus, the 1990 and 2001 estimates cannot be statistically compared. However, moose densities appeared similar between years.

Estimated moose densities were higher in Unit 20B West than in Units 20B Central or 20B East (Table 1). High moose density in the MFMA (1.9 moose/mi^2) probably influenced the overall Unit 20B estimate. Moose densities in Unit 20B West outside the MFMA were probably similar to densities observed throughout the remainder of Unit 20B. In Unit 20B Central, estimated densities were lower in 2001 (1.0 moose/mi^2) than in 1990 (1.2 moose/mi^2; McNay 1993) and 1994 (1.3 moose/mi^2). In contrast, estimated moose densities in Unit 20B West were higher in 1999 and 2001 (1.3–1.4 moose/mi^2) than in 1990 (0.9 moose/mi^2; McNay 1993).

Moose densities in the MFMA appeared to increase between 1989 (1.65 moose/mi^2; McNay 1993) and the mid 1990s (3 moose/mi^2 in 1997) and decline thereafter (Table 1). Productivity and/or early calf survival estimates support this observation. For instance, calf:100 cow ratios declined from 47:100 in 1994 and 1996 to 28:100 in 2001. Despite the apparent declines observed in the late 1990s, moose densities remained relatively high. Gasaway et al. (1992) reported that areas of Interior Alaska and the Yukon have densities of 0.1–1.1 moose/mi^2 where predators are lightly harvested. Higher densities occurred where wolves and/or bears were below food-limited levels. The MFMA has had relatively intensive wolf trapping efforts compared with most of Interior Alaska, and black bear harvest is also relatively high in roadside areas of Unit 20B.

Moose densities of 1.9 moose/mi^2 observed in the MFMA in 1999 and 2001 were lower than observed in 2000 (2.4 moose/mi^2). This difference probably resulted from low survey intensity (1999) and marginal snow conditions (2001). As a result, actual moose densities in the MFMA during those years were probably higher than estimated and probably exceeded 2 moose/mi^2. However, surveys in the MFMA also may have been influenced by changes in moose distribution due to the migratory nature of moose in the area and the timing of the October or November migration (P. Valkenburg and R. Boertje, ADF&G, personal observation). Therefore, inconsistent results may occur regardless of sampling effort. This problem was exacerbated by the relatively small size of the survey area. In addition, surveys were not directly comparable across years. For instance, the 1996 survey included 898 mi^2; whereas the 1997 survey included 967 mi^2, and most of the additional area (7.7%) included habitat with lower moose densities. Furthermore, the 1999 and 2001 surveys (951 mi^2) used the GSPE method, whereas previous surveys used Gasaway et al. (1986) methodology.

Moose densities in the FMA followed a trend similar to that observed in the MFMA (i.e., a decline in densities and productivity and/or early calf survival between the mid 1990s and 2001; Table 1). However, density in the FMA remained high, approaching or exceeding 1.5 moose/mi^2 since at least 1993.

I am uncertain whether the apparent trends in density, productivity and/or early calf survival observed in the MFMA and FMA occurred throughout Unit 20B, because unitwide surveys were conducted too infrequently to evaluate long-term trends in the data.

Population Composition

Bull:Cow Ratios. McNay (1993) reported that the overall Unit 20B bull:cow ratio averaged 40:100, well above the management objective of ≥30:100. The ratios varied by harvest intensity within the unit. For instance, the less intensively harvested Salcha River had bull:cow ratios of 44:100 (1990) and the MFMA had 49:100 (1989) and 47:100 (1994) (McNay 1993). In contrast, the more intensively harvested Chena River had 28:100 (1990), and the most intensively harvested FMA had 9–14:100 (1989–1994).

Surveys conducted in 2001 indicate a posthunting sex ratio of ≥30 bulls:100 cows unitwide and ≥20 bulls:100 cows in each count area (i.e., Unit 20B East, Unit 20B Central, Unit 20B West, and MFMA), except in the FMA (Table 1). Bull:cow ratios in the FMA have been low (≤15 bulls:100 cows) since the early 1990s (Table 1). Hunting pressure in the FMA was intense during the fall prior to surveys, and most bulls killed were yearlings. Low yearling bull:cow ratios observed during November surveys (e.g., 4:100 in 1993, 3:100 in 1994, 7:100 in 2001) resulted largely from the high proportion of yearling bulls killed in September and did not reflect poor calf recruitment. For example, we observed 39 calves:100 cows in 2001.

Calf:Cow Ratios. In general, calf:cow ratios declined between the mid 1990s and 2001 (Table 1). Calf:cow ratios tended to be higher in Unit 20B Central than Units 20B East and 20B West. The lowest ratios were observed in Unit 20B East (2001) and the highest were in the FMA (1994 and 1996). Elevated calf:cow ratios in the FMA and central Unit 20B were probably a function of lower predation rates resulting from lower predator abundance. Also, improved habitat existed in the FMA compared with Unit 20B East.

Twinning Rates

Twinning rates in the MFMA appeared to decline dramatically between 1997 and 2001 (Table 2). Higher estimates in 1997 and 1998 may be an artifact of low sample sizes, although the apparent decline in the MFMA was consistent with a similar decline observed on the Tanana Flats in Unit 20A, where twinning rates fell from 18% in 1996 to 3% in 1999 (Young 2000). Twinning rates improved in 2002 and 2003.

Distribution and Movements

Moose are distributed throughout Unit 20B, consisting of nonmigratory and migratory subpopulations (Gasaway et al. 1983). From February to April, some bull and cow moose migrate from the Chena and Salcha River drainages to calving areas on the Tanana Flats in Unit 20A. Most remain there for the summer and return to the foothills from August through October. Although we do not know what proportion of the moose migrate, Gasaway et al. (1983) estimated that seasonal migrants probably increase the density of moose on the Tanana Flats 2- to 4-fold. Therefore, the spring and summer densities in Unit 20B are probably much lower than during winter.

MORTALITY

Harvest

Season and Bag Limit. Seasons and bag limits in Unit 20B in RY01 were:

Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Fairbanks Management Area.		
1 antlerless moose by bow and arrow by drawing permit; or	1 Sep–30 Sep 21 Nov–27 Nov	1 Sep–30 Sep 21 Nov–27 Nov
1 bull with antlers by bow and arrow.	1 Sep–30 Sep 21 Nov–27 Nov	1 Sep–30 Sep 21 Nov–27 Nov
Minto Flats Management Area.		
1 moose by Tier II permit only; or	1 Sep–20 Sep 10 Jan–28 Feb	No open season
1 bull with spike-fork or 50-inch antlers, or with at least 4 brow tines on 1 side.	11 Sep–20 Sep	No open season
Middle Fork drainage of Chena River, and Salcha		

Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
River drainage upstream from and including Goose Creek.		
1 bull.	1 Sep–20 Sep	1 Sep–20 Sep
Remainder of Unit 20B.		
1 bull.	1 Sep–15 Sep	5 Sep–15 Sep

Seasons and bag limits in Unit 20B in RY02 were:

Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Fairbanks Management Area.		
1 antlerless moose by bow and arrow by drawing permit;	1 Sep–30 Sep 21 Nov–27 Nov	1 Sep–30 Sep 21 Nov–27 Nov
or		
1 bull with antlers by bow and arrow.	1 Sep–30 Sep 21 Nov–27 Nov	1 Sep–30 Sep 21 Nov–27 Nov
Minto Flats Management Area.		
1 moose by Tier II permit only;	1 Sep–20 Sep 10 Jan–28 Feb	No open season
or		
1 bull with spike-fork or 50-inch antlers, or with at least 4 brow tines on 1 side.	11 Sep–20 Sep	No open season
Middle Fork drainage of Chena River, and Salcha River drainage upstream from and including Goose Creek.		
1 bull by permit (TACH);	3 Aug–6 Aug	3 Aug–6 Aug
or		
1 bull;	1 Sep–20 Sep	1 Sep–20 Sep

Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
or		
1 bull by bow and arrow.	21 Sep–30 Sep	21 Sep–30 Sep
Remainder of Unit 20B.		
1 bull by permit (TACH);	3 Aug–6 Aug	3 Aug–6 Aug
or		
1 bull.	1 Sep–15 Sep	5 Sep–15 Sep

Alaska Board of Game Actions and Emergency Orders.

Historical Board of Game Actions — In the MFMA, the department issued 150 Tier II permits per year from RY90 through RY92 to provide for an annual harvest quota of 50 bulls. However, harvests were only 28–42 per year. In spring 1993 we calculated a new harvest quota of 100 bulls and recommended the Board of Game authorize up to 250 permits. The board passed our recommendation, and the department issued 200 permits in RY93 and RY94. In spring 1995 the board approved changes for the MFMA and FMA. The Tier II bag limit was changed from any bull to any moose, and the number of permits was reduced to 60. A general hunt was added for bulls with spike-fork or 50-inch antlers or antlers with 4 or more brow tines with a shorter season than the Tier II hunt. In RY96 the number of Tier II permits was increased to 100, where it remained through RY03.

The board also approved a drawing hunt for antlerless moose in the FMA beginning in RY95 and replaced the registration hunt with a general season. In RY00 the number of FMA antlerless moose permits that could be issued was increased from 25 to 100 in response to high moose densities and the increasing number of moose–vehicle collisions and moose–human conflicts in the Fairbanks area. Also, the FMA antlerless moose hunt was liberalized to include a 21–27 November season to align the bull and antlerless seasons, increase the harvest of cows, and provide additional hunting opportunity. In addition, the FMA was enlarged from approximately 217 mi^2 to 318 mi^2 to clarify boundaries in the Cripple Creek and Goldstream areas and to address safety issues in developed areas in the Goldstream Valley and Chena Hot Springs Road/Nordale areas (*FMA boundary description: that portion of Unit 20(B) bounded by a line from the confluence of Rosie Creek and the Tanana River, northerly along Rosie Creek to Isberg Road, then northeasterly on Isberg Road to Cripple Creek Road, then northeasterly on Cripple Creek Road to the Parks Highway, then north on the Parks Highway to Alder Creek, then westerly along Alder Creek to its confluence with Emma Creek, then upstream along Emma Creek to its headwaters, then northerly along the hydrographic divide between Goldstream Creek drainages and Cripple Creek drainages to the summit of Ester Dome, then down Sheep Creek to its confluence with Goldstream Creek, then easterly along Goldstream Creek to Sheep Creek Road, then north on Sheep Creek Road to Murphy Dome Road, then west on Murphy Dome Road to Old Murphy Dome Road, then east on Old Murphy Dome Road to the Elliot Highway, then south on the Elliot Highway to Goldstream Creek, then easterly along Goldstream Creek to its confluence with First Chance Creek, then up First Chance Creek to*

Tungsten Hill, then southerly along Steele Creek to its confluence with Ruby Creek, then upstream along Ruby Creek to Esro Road, then south on Esro Road to Chena Hot Springs Road, then east on Chena Hot Springs Road to Nordale Road, then south on Nordale Road to the Chena River, then along the north bank of the Chena River to the Moose Creek dike, then southerly along Moose Creek dike to its intersection with the Tanana River, and then westerly along the north bank of the Tanana River to the point of beginning). However, during the spring 2002 meeting, the Board of Game again modified the boundaries of the FMA in the Cripple Creek, Fox, and Steele Creek areas (*FMA boundary description: that portion of Unit 20(B) bounded by a line from the confluence of Rosie Creek and the Tanana River, northerly along Rosie Creek to the middle fork of Rosie Creek through Section 26 to the Parks Highway, then east along the Parks Highway to Alder Creek, then upstream along Alder Creek to its confluence with Emma Creek, then upstream along Emma Creek to its headwaters, then northerly along the hydrographic divide between Goldstream Creek drainages and Cripple Creek drainages to the summit of Ester Dome, then down Sheep Creek to its confluence with Goldstream Creek, then easterly along Goldstream Creek to Sheep Creek Road, then north on Sheep Creek Road to Murphy Dome Road, then west on Murphy Dome Road to Old Murphy Dome Road, then east on Old Murphy Dome Road to the Elliot Highway, then south on the Elliot Highway to Davidson Ditch, then southeasterly along the Davidson Ditch to its confluence with the tributary to Goldstream Creek in Section 29, then downstream along the tributary to its confluence with Goldstream Creek, then in a straight line to First Chance Creek, then up First Chance Creek to the summit of Tungsten Hill, then southerly along Steele Creek to its intersection with the trans-Alaska pipeline right-of-way, then southeasterly along the easterly edge of the trans-Alaska pipeline right-of-way to the Chena River, then along the north bank of the Chena River to the Moose Creek dike, then southerly along Moose Creek dike to its intersection with the Tanana River, and then westerly along the north bank of the Tanana River to the point of beginning*).

Report Period Board of Game Actions — The Board of Game adopted intensive management population (12,000–15,000 moose) and harvest (600–1500 moose) objectives for Unit 20B in November 2000, and at the spring 2002 meeting added a 21–30 September hunt by bow and arrow only in the drainage of the Middle (East) Fork of the Chena River and Salcha River upstream from and including Goose Creek, and created a 3–6 August Take a Child Hunting youth (8–17 years of age) hunt for any bull in Unit 20B, excluding the FMA and MFMA.

Spring 2004 Alaska Board of Game Actions — The board eliminated the Take a Child Hunting early season hunt for moose in Unit 20B; created a new winter (21–27 Nov) drawing permit hunt for antlerless moose by muzzleloader only in Creamer's Refuge; increased the number of antlerless drawing permits for the FMA from 100 to 150, and prohibited drawing permit winners for antlerless hunts in the area from taking an antlered bull in the management area; and in the MFMA changed the Tier II hunt to a registration hunt and lengthened the fall seasons (general and registration) to 1–25 September.

Hunter Harvest.

General Season — The reported harvest of 506 bulls in RY01 was 15% lower than the average reported harvest of 598 bulls during RY97–RY02 (Table 3). This appeared to be the combined result of reduced effort and lower success rates. The reduced effort may be explained by the large number of soldiers from Fort Wainright deployed outside of Alaska during September

2001. Lower success rates of 18% versus 20% for the period RY97–RY02 was likely a function of weather.

The majority of harvest was in Unit 20B Central, followed by Unit 20B West, then Unit 20B East (Table 3). Harvest density (moose harvested/mi^2) in Unit 20B Central was over 2.5 times that reported in Units 20B East and 20B West. Like calf:cow ratios, this is probably a function of higher moose densities due to lower predator densities and better habitat in Unit 20B Central than in Unit 20B West and 20B East.

Drawing Permit Hunts — Few trends were apparent in harvest, effort or success rates from RY97 through RY02 in hunts DM788 or TM785 (Table 4). However, the proportion of DM788 permit holders choosing not to hunt increased from 7% (RY97–RY00) to 16% in RY01–RY02. Harvest rates of bulls and cows remained stable in hunt TM785.

Hunter Residency and Success. Primarily local residents hunted moose in Unit 20B (Table 3). Participation by nonlocal residents and nonresidents was relatively low.

Hunter success during the general season was generally lower in Unit 20B than elsewhere in Unit 20. For example, between RY97 and RY02, 18–23% of the hunters in Unit 20B were successful (Table 3), whereas annual success rates in Units 20A and 20C typically exceed 35% (Young 2000). Success rates in RY01 and RY02 were similar to the average success rate of 20% reported for the period RY97–RY02. During the previous reporting period, Unit 20B Central had lower success rates ($\bar{x}$ = 19%) than Units 20B West ($\bar{x}$ = 23%) and Unit 20B East ($\bar{x}$ = 28%). Typically, success rates are lower in areas with higher hunter densities and/or lower bull:cow ratios, such as Unit 20B Central, and higher in areas with lower hunter densities and/or higher bull:cow ratios, such as Unit 20B East. However, during this reporting period Unit 20B East ($\bar{x}$ = 21.5%), Unit 20B Central ($\bar{x}$ = 20%), and Unit 20B West ($\bar{x}$ = 21%) all had similar success rates.

In the FMA, harvests were relatively high during the past 8 years (Young 2002; this report). The high harvests were probably the result of high densities and survival rates of moose in the FMA during that period. Population estimates and anecdotal information indicate that moose densities, productivity, and early calf survival were high in the FMA between 1993 and 2001 (Table 1).

Harvest Chronology. Between RY97 and RY00, more bull moose were killed during the first 5 days of the season than during any other 5-day period (Table 5). However, during the RY01–RY02 reporting period, harvest shifted slightly towards the later part of the season (i.e., 11–15 Sep).

Transport Methods. Highway vehicles were the primary method of transportation used by successful hunters (Table 6). Since RY97 the proportion of successful hunters using 3- or 4-wheelers and boats (traditional and airboats) increased slightly, while the proportion using highway vehicles and airplanes declined somewhat. No other trends were apparent.

Other Mortality

The number of moose killed in accidents with motor vehicles and trains has been substantial in some years (Table 7). The number of moose reported killed on highways in the FMA averaged

100 animals annually RY97–RY02. By comparison, an average of only 64 moose was reported harvested annually by hunters in the FMA during that same period. An additional 65.5 moose were killed each year on roads in the remainder of Unit 20B. Few moose were reported killed by trains during RY97 through RY02, with the exception of RY99 when 61 were reported killed.

HABITAT

Assessment/Enhancement

Surveys conducted in spring 2003 indicated that moose utilization of preferred browse species in the MFMA was higher than any other area sampled in Interior Alaska (Fig 1). As a result, I recommended the Board of Game increase harvest of moose in the MFMA to limit population growth.

The department is planning and/or conducting moose habitat enhancement for portions of the Fairbanks area. These efforts include use of prescribed fire and regeneration of decadent willows by planting willows in recently logged areas. In addition, existing habitat improvement projects for grouse in Unit 20B have positive benefits for moose.

The proposed Nenana Basin Gas Lease could potentially fragment important moose habitat in the Minto Flats area. Development could affect moose in 2 ways. First, pipelines and roads may improve access. More important, increased fire suppression near wells and structures may adversely affect habitat capability for moose. The Division of Wildlife Conservation forwarded these concerns via comments submitted in response to the Alaska Department of Natural Resources, Division of Oil and Gas Preliminary Best Interest Finding.

NONREGULATORY MANAGEMENT PROBLEMS/NEEDS

During this reporting period we collected systematic information on nonhunting mortality of moose because of its potential influence on harvest quotas and population trends. Motor vehicle and railroad kills continue to be an important source of mortality (Table 7). Within the Fairbanks urban area, we also received a considerable number of complaints about human–moose conflicts, such as moose in gardens or yards, moose attacking dogs along dogsled trails, and moose "trapped" within the confines of the urban area. For instance, in RY01 and RY02 the department recorded 71 and 114 complaints, respectively, involving moose within Unit 20B. Department policy for the treatment of nuisance moose should be formalized for public consideration. Mitigation measures, including public education, are continuing.

CONCLUSIONS AND RECOMMENDATIONS

Surveys conducted in 2001 indicate we met our management objective of a posthunting sex ratio of ≥30 bulls:100 cows unitwide and ≥20 bulls:100 cows in each count area (i.e., Unit 20B East, Unit 20B Central, Unit 20B West, and MFMA), except in the FMA. Low bull:cow ratios in the FMA, a relatively small area, are of less concern than in larger areas because the FMA is small in relation to the annual home range of moose. If not enough bulls are available in the FMA for breeding, cows in estrous can easily move to the periphery or outside the FMA where bull:cow ratios are higher, and bulls seeking females can readily migrate into the FMA. High calf:cow ratios also indicate there have been sufficient bull moose in the FMA to breed cows in estrous.

We probably did not meet the intensive management population objective of 12,000–15,000 moose established for Unit 20B by the Board of Game, although the actual total population (estimated observed moose × sightability correction factor) probably approached 12,000 moose. Reported harvest reached the intensive management harvest objective lower limit of 600 moose in RY02 (n = 788), but not in RY01 (n = 590).

I concur with Dale (1998) that we need to collect unitwide population data on an annual basis to better assess the status of the population, then reevaluate management objectives and gain public approval of those management objectives.

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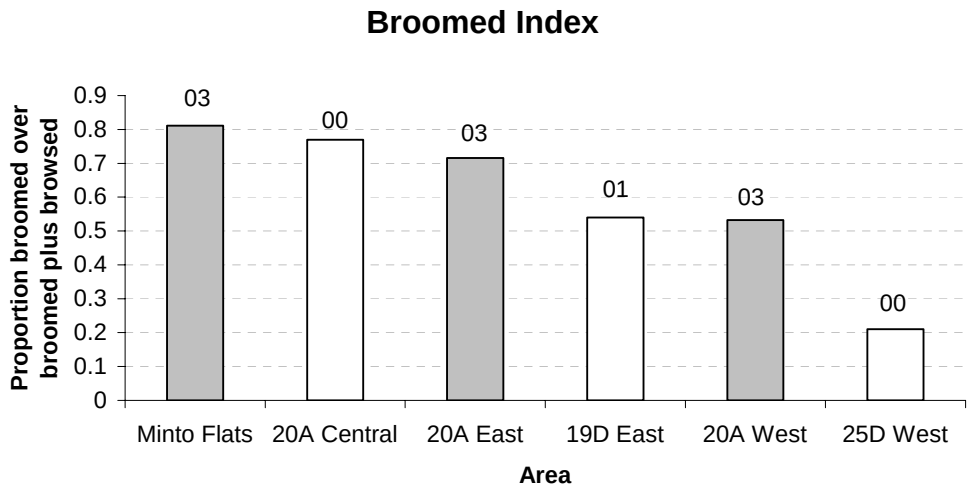

FIGURE 1 Index of proportion of preferred browse species (*Salix* spp., birch and aspen) that were broomed in the Minto Flats Management Area in spring 2003 relative to 5 other areas sampled in Interior Alaska

TABLE 1 Unit 20B aerial moose fall composition counts and estimated population size, regulatory years 1993–1994 through 2003–2004

Count area	Regulatory year	Bulls:100 Cows	Yearlings: 100 Cows[a]	Calves:100 Cows	Percent calves	Adults	Moose observed	Moose/mi^2	Estimated population size (90% CI)
Unit 20B	2001–2002	33	15	30	18	751	914	1.1[b]	10,261 (±17%)
Unit 20B	2003–2004	34	24	37	22	399	514	1.4[b]	12,904 (±23%)
Unit 20B East[c]	2001–2002	47	15	24	11	271	305	1.0[b]	2454 (±22%)
Unit 20B Central[d]	1994–1995	18	5	47	28		428	1.3[e]	
Unit 20B Central[f]	2001–2002	27	13	34	26	205	278	1.0[b]	4005 (±25%)
Unit 20B West[g]	1999–2000	27	14	34	20	438	546	1.4[b]	4881 (±20%)
Unit 20B West[h]	2001–2002	30	16	29	17	274	331	1.3[b]	3802 (±22%)
MFMA[i,j]	1994–1995	47	11	47	24		489	2.9[k]	
MFMA[j]	1996–1997	27	27	47	27			3.0[l]	2627 (±14%)
MFMA[m]	1997–1998	33	15	34			647	2.7[l]	2604 (±45%)
MFMA[n]	1999–2000	31	16	36	19	374	463	1.9[b]	1778 (±20%)
MFMA[n]	2000–2001	31	8	39	24	546	714	2.4[b]	2200 (±14%)
MFMA[n]	2001–2002	30	16	28	17	191	230	1.9[b]	1877 (±21%)
FMA[o,p]	1993–1994	9	8	30	27		65	1.3	
FMA[q]	1994–1995	14	6	61	40		165	2.6[e]	
FMA[q]	1996–1997	15	23	52	32	101	150	1.9	
FMA[r]	2001–2002	12	13	39	28	70	99	1.4[b]	461 (±34%)

[a] Yearlings:100 cows = Yearling bulls:100 cows × 2.
[b] Geostatistical Population Estimation method does not incorporate a SCF (see methods).
[c] A 2425-mi^2 count area.
[d] A 642-mi^2 count area north and west of Fairbanks.
[e] Corrected for sightability (SCF = 1.23).
[f] A 3829-mi^2 count area.
[g] A 3644-mi^2 count area encompassing most of Unit 20B West (3955 mi^2), including the MFMA.
[h] A 2942-mi^2 count area.
[i] Minto Flats Management Area.
[j] An 898-mi^2 count area.
[k] Corrected for sightability (SCF = 1.13).
[l] Corrected for sightability (SCF = 1.18).
[m] A 967-mi^2 count area.
[n] A 951-mi^2 count area.
[o] Fairbanks Management Area.
[p] A 52-mi^2 count area within the FMA.
[q] A 78-mi^2 count area within the FMA.
[r] A 318-mi^2 count area.

TABLE 2 Results of twinning rate surveys for moose in Unit 20B (Minto Flats Management Area), 1997–2003

		Cows			
Year	Date	w/Single calf	w/Twins	Total	% Twins[a]
1997	22 May	17	9	26	35
1998	31 May	18	5	23	22
1999	27–29 May	59	4	63	6
2000	30–31 May	74	10	84	12
2001	31 May	58	5	63	8
2002	29 May	38	10	48	21
2003	29 May	40	10	50	20

[a] Percentage of cows with calves that had twins.

TABLE 3 Unit 20B moose hunter[a] residency and success, regulatory years 1997–1998 through 2002–2003

Area/ Regulatory year	Successful						Unsuccessful					Total hunters
	Local[b] resident	Nonlocal resident	Nonresident	Unk	Total	% Successful	Local[b] resident	Nonlocal resident	Nonresident	Unk	Total	
Unit 20B East (UCUs 601, 602, 603, 604, 605)												
1999–2000	70	12	6	1	89	27	214	17	10	2	243	332
2000–2001	76	14	9	0	99	28	222	20	9	0	251	350
2001–2002	49	3	9	1	62	20	212	18	18	0	248	310
2002–2003	78	8	7	0	93	23	260	28	22	0	310	403
Unit 20B Central (UCUs 207, 208, 209, 211, 212, 213, 301, 401, 402, 403, 404, 405, 406, 501)												
1999–2000	281	22	25	2	330	19	1263	74	77	7	1421	1751
2000–2001	269	30	28	0	327	19	1257	75	90	8	1430	1757
2001–2002	241	16	20	2	279	19	1009	77	84	4	1174	1453
2002–2003	275	40	20	1	336	21	1095	82	50	6	1233	1569
Unit 20B West (UCUs 101, 201, 202, 203, 204, 205, 206, 210)												
1999–2000	92	14	8	0	114	26	269	41	19	2	331	445
2000–2001	69	17	5	1	92	19	305	59	28	2	394	486
2001–2002	58	18	9	0	85	20	249	67	23	2	341	426
2002–2003	72	22	8	0	102	22	256	71	22	3	352	454
FMA general archery hunt (UCUs 0212, 0213, 0300, 0301, 0401, 0402, 0403, 0501; archery only)												
1997–1998[c]	44	0	0	0	44[d]							
1998–1999[c]	35	1	1	0	37[d]							
1999–2000[c]	35	0	0	0	35[d]							
2000–2001[e]	46	1	1	0	48[d]							
2001–2002[e]	38	1	1	0	40[d]							
2002–2003[e]	44	3	1	0	48[d]							
MFMA general hunt (UCUs 0201, 0205, 0210; Nonresident hunters and antlerless harvest censored)												
1997–1998	37	7	0	0	44	39	65	4	0	0	69	113
1998–1999	44	12	0	1	57	32	112	6	0	1	119	176
1999–2000	43	5	0	0	48	27	119	10	0	1	130	178
2000–2001	40	7	0	0	47	27	111	13	0	0	124	171
2001–2002	27	9	0	0	36	26	80	19	0	1	100	136
2002–2003	40	12	0	0	52	30	103	20	0	1	124	176

Area/ Regulatory year	Successful						Unsuccessful					Total hunters
	Local[b] resident	Nonlocal resident	Nonresident	Unk	Total	% Successful	Local[b] resident	Nonlocal resident	Nonresident	Unk	Total	
Unit 20B remainder general hunt (Includes FMA general archery hunt, but excludes MFMA)												
1997–1998	446	31	34	2	513	19	1925	124	92	20	2161	2674
1998–1999	529	43	46	3	621	22	1944	130	123	17	2214	2835
1999–2000	457	46	47	4	554	20	1907	156	113	13	2189	2743
2000–2001	438	69	43	0	550	20	1953	170	137	10	2270	2820
2001–2002	388	35	44	3	470	18	1845	187	145	7	2184	2654
2002–2003	475	76	43	2	596	20	1991	226	110	9	2336	2932
All general hunts												
1997–1998	483	38	34	2	557	20	1990	128	92	20	2230	2787
1998–1999	573	55	46	4	678	23	2055	137	123	18	2333	3011
1999–2000	500	51	47	4	602	21	2026	166	113	14	2319	2921
2000–2001	478	76	43	0	597	20	2064	183	137	10	2394	2991
2001–2002	415	44	44	3	506	18	1925	206	145	8	2284	2790
2002–2003	515	88	43	2	648	21	2094	246	110	10	2460	3108

[a] Excludes drawing and Tier II permit hunt harvest.

[b] Residents of Unit 20.

[c] FMA approx. 230 mi^2.

[d] Subtracted number of bulls reported harvested by bow and arrow on Eielson AFB (in UCU 0501, but outside FMA).

[e] FMA approx. 330 mi^2.

TABLE 4 Unit 20B moose harvest data by permit hunt, regulatory years 1996–1997 through 2002–2003

Hunt	Regulatory year	Permits issued	Did not hunt	(%)	Unsuccessful hunters	(%)	Successful hunters	(%)	Bulls	(%)	Cows	(%)	Unk	(%)	Harvest
DM788	1996–1997	15	1	(7)	7	(50)	7	(50)	0	(0)	7	(100)	0	(0)	7
	1997–1998	25	2	(8)	9	(39)	14	(61)	0	(0)	14	(100)	0	(0)	14
	1998–1999	25	0	(0)	9	(36)	16	(64)	0	(0)	16	(100)	0	(0)	16
	1999–2000	25	2	(8)	12	(52)	11	(48)	0	(0)	11	(100)	0	(0)	11
	2000–2001	50	5	(10)	18	(40)	27	(60)	0	(0)	27	(100)	0	(0)	27
	2001–2002	75	14	(19)	33	(54)	28	(46)	2	(7)	26	(93)	0	(0)	28
	2002–2003	75	10	(13)	28	(43)	37	(57)	3	(8)	34	(92)	0	(0)	37
TM785	1996–1997	100	20	(20)	30	(38)	50	(62)	27	(54)	23	(46)	0	(0)	50
	1997–1998	100	17	(17)	30	(36)	53	(64)	30	(57)	23	(43)	0	(0)	53
	1998–1999	100	17	(17)	24	(29)	59	(71)	32	(54)	27	(46)	0	(0)	59
	1999–2000	100	22	(22)	21	(27)	57	(73)	34	(60)	23	(40)	0	(0)	57
	2000–2001	100	15	(15)	31	(36)	54	(64)	28	(52)	25	(46)	1	(2)	54
	2001–2002	100	17	(17)	26	(31)	57	(69)	31	(54)	26	(46)	0	(0)	57
	2002–2003	100	16	(16)	32	(38)	52	(62)	30	(58)	22	(42)	0	(0)	52
YM301	2002–2003	257	36	(14)	170	(77)	51	(23)	51	(100)	0	(0)	0	(0)	51
Totals for all permit hunts	1996–1997	115	21	(18)	37	(39)	57	(61)	27	(47)	30	(53)	0	(0)	57
	1997–1998	125	19	(15)	39	(37)	67	(63)	30	(45)	37	(55)	0	(0)	67
	1998–1999	125	17	(14)	33	(31)	75	(69)	32	(43)	43	(57)	0	(0)	75
	1999–2000	125	24	(19)	33	(33)	68	(67)	34	(50)	34	(50)	0	(0)	68
	2000–2001	150	20	(13)	49	(38)	81	(62)	28	(35)	52	(64)	1	(1)	81
	2001–2002	175	31	(18)	59	(41)	85	(59)	33	(39)	52	(61)	0	(0)	85
	2002–2003	432	62	(14)	230	(62)	140	(38)	84	(60)	56	(40)	0	(0)	140

TABLE 5 Unit 20B moose harvest[a] chronology percent by month/day, regulatory years 1997–1998 through 2002–2003

Regulatory year	Harvest chronology percent by month/day						
	9/1–9/5	9/6–9/10	9/11–9/15	9/16–9/20	9/21–9/25	Unk/Other	*n*
1997–1998	33	25	27	6	3	6	557
1998–1999	35	25	28	6	1	4	679
1999–2000	33	25	30	7	1	4	602
2000–2001	37	22	28	6	2	5	593
2001–2002	27	27	33	5	1	7	506
2002–2003	32	23	33	6	1	5	648

[a] Excludes drawing and Tier II permit hunt harvest.

TABLE 6 Unit 20B moose harvest[a] percent by transport method, regulatory years 1997–1998 through 2002–2003

Regulatory year	Harvest percent by transport method									
	Airplane	Horse	Boat	3- or 4-wheeler	Snowmachine	Other ORV	Highway vehicle	Airboat	Other/ Unknown	*n*
1997–1998	5	0	18	26		5	42	1	3	557
1998–1999	3	0	20	30		3	41	2	2	679
1999–2000	3	1	19	29	0	4	39	2	3	602
2000–2001	3	0	21	29	0	4	35	3	4	593
2001–2002	3	0	21	31	0	4	34	3	2	506
2002–2003	3	0	21	29	0	5	36	2	3	648

[a] Excludes drawing and Tier II permit hunt harvest.

TABLE 7 Estimate of Unit 20B moose harvest[a] and accidental death, regulatory years 1997–1998 through 2002–2003

	Harvest by hunters							Accidental death					
	Reported				Estimated			Road[b]					
Regulatory year	M	F	Unk	Total	Unreported[c]	Illegal/ Other[d]	Total	FMA[e]	Unit 20B remainder	Total	Train[f]	Total	Total
1997–1998	586	37	1	624	110	79	189	97	70	167	15	182	995
1998–1999	709	43	2	754	133	65	198	93	73	166	13	179	1131
1999–2000	624	34	12	670	119	96	215	117	75	192	61	253	1138
2000–2001	611	58	9	678	120	44	164	105	52	157	9	166	1008
2001–2002	531	53	6	590	104	38	142	71	50	121	9	130	862
2002–2003	725	61	2	788	139	32	171	116	73	189	12	201	1160

[a] Includes general and permit hunt harvest.
[b] Documented kills; actual number killed by vehicles is certainly greater.
[c] Based on 17.7% unreported harvest (including wounding loss) estimated by Gasaway et al. (1992).
[d] Includes illegal, DLP, dispatched, potlatch, stickdance, and other reported deaths.
[e] Fairbanks Management Area.
[f] Confirmed dead between Alaska Railroad mileposts 411.8 and 470.0; "Missing" (moose hit but not recovered) are not included. Data provided by the Alaska Railroad.

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MOOSE MANAGEMENT REPORT

From: 1 July 2001
To: 30 June 2003

LOCATION

GAME MANAGEMENT UNITS: 20C (11,902 mi^2), 20F (6267 mi^2), and 25C (5149 mi^2)

GEOGRAPHIC DESCRIPTION: Unit 20C includes drainages into the west bank of the Nenana River, and into the south bank of the Tanana River west of the Nenana River. Most of Denali National Park and Preserve is within Unit 20C. Unit 20F includes drainages into the north bank of the Tanana River west of Manley Hot Springs, and into the Yukon River drainage in the area between the village of Tanana and the Dalton Highway bridge. Unit 25C includes drainages into the south bank of the Yukon River upstream from Circle to, but not including, the Charley River drainage; the Birch Creek drainage upstream from the Steese Highway Bridge; the Preacher Creek drainage upstream from and including the Rock Creek drainage; and the Beaver Creek drainage upstream from and including the Moose Creek drainage.

BACKGROUND

Moose densities in Units 20C, 20F, and 25C have been low for many years, presumably because of combined predation from wolves and bears (Gasaway et al. 1992) and habitat limitations. Wolf and bear populations are lightly harvested. Bull moose harvest is low relative to population size, and the proportion of large bulls in the harvest remains relatively high. Therefore, harvest is a minor factor affecting population dynamics relative to predation.

These units contain some large tracts of mature black spruce that are poor quality moose habitat. However, many riparian areas, subalpine hills, and burns appear to have habitat capable of supporting moose at relatively high densities (≥2 moose/mi^2).

Trends in moose populations have been difficult to identify, but densities probably fluctuate within 0.1 and 1.1 moose/mi^2, and more likely between 0.2 to 0.7 moose/mi^2 based on Alaska and Yukon studies in large areas (>800 mi^2) with 2 or more lightly-harvested predators (Gasaway et al. 1992).

Moose within Denali National Park and Preserve (DNPP) have been studied more intensively than moose in the rest of the units. These studies include movement and behavior of

radiocollared moose, composition surveys, and population estimates conducted by DNPP biologists since 1970.

Moose in these units are an important source of food and/or trophies for many local rural residents and other residents throughout Interior Alaska.

MANAGEMENT DIRECTION

MANAGEMENT GOALS

- Provide for a sustained harvest of these low-density populations.
- Promote moose habitat enhancement by allowing natural fires to alter vegetation.

MANAGEMENT OBJECTIVE

- Maintain a bull:cow ratio of ≥ 30:100.

METHODS

Pilot Troy Cambier and observer Tom Seaton conducted aerial moose composition counts from a PA-18 Super Cub in the O'Brien Creek and Ophir Creek survey areas of Unit 25C on 16 November 2002. Prior to that, the last composition count in Unit 25C was conducted in 1996. The O'Brien Creek survey area was the same area surveyed in 1986–1996 surveys. To increase the sample size of moose observed for compositional analysis, we did additional composition counts in 1996 and 2002 along the riparian zones south of the O'Brien Creek count area in the drainages of Trail, O'Brien, Champion, Beaver, Ophir, Roy, Little Champion and Nome Creeks. I named this new composition count area the Ophir Creek count area. Habitat in the Ophir Creek count area was dominated by short black spruce, with the exception of riparian habitat along the creeks. The riparian zones were 5–200 meters wide, and represented a large proportion of the forage available for moose in early winter. A single pass was flown along most narrow (<50 m width) riparian zones and 2 passes were flown along most wider riparian zones.

We completed a Geostatistical Population Estimator (GSPE; Ver Hoef 2001) moose survey in Unit 25C (5000 mi^2) during November–December 1997 in cooperation with the Bureau of Land Management (BLM). This is a recently derived technique that does not yet commonly incorporate a sightability correction factor (SCF), but preliminary data suggest a SCF of 1.1 to 1.2 is appropriate for most of these units if October or November surveys are flown with good survey conditions. DNPP biologists conducted a census using Gasaway methods (Gasaway et al. 1986) during November 1994 in the Lake Minchumina Area (1007 mi^2) of Unit 20C. Stratification flights associated with the GSPE technique were completed for that portion of Unit 20C outside of DNPP on 19 December 2000.

We estimated annual moose mortality using (1) data from harvest report cards after sending reminder letters to increase response, (2) our records of telephone calls from the public concerning nonhunting mortality, (3) Bureau of Wildlife Enforcement records of moose–motor vehicle collisions, and (4) Alaska Railroad records of moose–train collisions between

railroad mileposts 327–371 in Unit 20C. Also, to estimate unreported harvest in the village of Tanana, we used a 1987 study conducted by the ADF&G/Division of Subsistence. Data were summarized by regulatory year (RY), which begins 1 July and ends 30 June (e.g., RY01 = 1 Jul 2001–30 Jun 2002).

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Population Size

Based on the 1997 GSPE without an SCF, we estimated Unit 25C moose density at 0.46 moose/mi^2 of moose habitat, with a total population estimate of 2279 moose (90% CI ±16.5%). With an SCF of 1.12, the actual moose density would be 0.5 moose/mi^2. We expected this low estimate because all large areas of Interior Alaska (>800 mi^2) with lightly harvested bear and wolf populations currently have moose densities with an average of about 0.6 moose/mi^2. Very few moose density estimates have been outside this range of 0.2–0.8 moose/mi^2 during the last 30 years, except in areas where predation is reduced by humans.

We estimated 3500–4500 moose inhabited Unit 20C moose habitat: 2000 within Denali National Park and 1500–2500 outside Denali National Park (including Denali National Preserve). These estimates assumed an average density of 0.58 moose/mi^2 inside Denali National Park [Oct 1991 census; T. Meier, National Park Service (NPS), personal communication] and 0.25 moose/mi^2 outside Denali National Park. Based on a November 1994 survey, Denali Park biologists estimated the density of the Lake Minchumina area at 0.34 moose/mi^2 (K. Stahlnecker, NPS, personal communication).

We estimated 1000–2000 moose resided in Unit 20F. This assumed 0.25–0.50 moose/mi^2, with roughly 4250 mi^2 of moose habitat (McNay 1990).

Population Composition

During the 2002 aerial moose composition counts in Unit 25C, snow cover was complete, weather was clear, and light intensity was bright to medium. There were 71 and 59 bulls per 100 cows in the O'Brien Creek and Ophir Creek survey areas, respectively, and 9 and 19 calves per 100 cows (Table 1). High annual variability in the observed number and population composition of moose throughout most of the composition surveys in Unit 25C is probably due to variations in moose distribution at survey time rather than true moose density, population composition, or search effort. Therefore, the 1997 large-scale population estimate probably best represents moose density and composition in Unit 25C. Results from the 1997 GSPE in Unit 25C included estimates of 53 bulls:100 cows and 37 calves:100 cows. We conclude that harvest has minimal impact on the Unit 25C moose population. If harvest rates of bulls were high, the bull:cow ratio would decline within a few years.

Population composition data in Units 20C and 20F were limited to the percentage of large bulls (antlers wider than 50 inches) in the harvest (Fig 1). If harvest rates of bulls were too high to be sustainable, the percentage of large bulls in the harvest would decline within a few years. The percentage of large bulls in the reported harvest was relatively stable in Unit 20C between RY95 and RY00 (30–40%), and steadily increased during RY01–RY03 to 50% in

RY03. The percentage of large bulls in the Unit 20F reported harvest was more stable RY01–RY03 than it had been over the previous decade, with a mean of 41%. These data suggest there was no danger of overharvest of bulls in these units during RY95–RY03.

MORTALITY

Harvest

Season and Bag Limit. Hunting seasons and bag limits have not changed since RY93 (Table 2).

Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Unit 20C		
RESIDENT HUNTERS: 1 bull; however, white-phased or partial albino (more than 50% white) moose may not be taken.	1 Sep–20 Sep	
NONRESIDENT HUNTERS: 1 bull; however, white-phased or partial albino (more than 50% white) moose may not be taken.		5 Sep–15 Sep
Unit 20F, drained by the Yukon River excluding the Tanana River drainage downstream from the drainage of Hess Creek.		
RESIDENT HUNTERS: 1 bull.	1 Sep–20 Sep or 1 Dec–10 Dec	No open season
Unit 20F, drained by the Tanana River.		
RESIDENT HUNTERS: 1 bull.	1 Sep–20 Sep	No open season
Remainder of Unit 20F		
RESIDENT HUNTERS: 1 bull.	1 Sep–15 Sep	No open season
Unit 25C		
RESIDENT HUNTERS: 1 bull.	1 Sep–15 Sep	
NONRESIDENT HUNTERS: 1 bull.		5 Sep–15 Sep

Alaska Board of Game Actions and Emergency Orders. No Board of Game actions were taken and no emergency orders were issued during this reporting period.

Hunter Harvest. Between RY98 and RY02 reported moose harvest was stable or slightly decreasing in Units 20C, 20F, and 25C (Table 2). During this time, the reported harvest was 131–140 moose in Unit 20C, 29–45 in Unit 20F, and 61–84 in Unit 25C.

Unreported Harvest and Estimated Nonhunting Mortality — We cannot easily estimate the number of unreported kills in Units 20C, 20F, and 25C. Harvest report cards returned by residents of Tanana, Rampart, Manley, Livengood, Central, Circle, and Circle Hot Springs likely represent minimal harvest reporting. For example, information collected by the Division of Subsistence indicates that only 10–20% of the actual harvest by Tanana residents was reported. The reporting rate for other rural communities in this area is unknown.

Illegal, other, and motor vehicle deaths were obtained from the Fairbanks Bureau of Wildlife Enforcement wildlife mortality logs. Data concerning deaths caused by train collisions (only applicable for Unit 20C) were obtained from the Alaska Railroad. Documented causes of accidental mortality were minimal (0–3 annually) in Unit 20F and Unit 25C, but higher in Unit 20C (0–21 annually) due to deaths caused by train collisions (Table 3).

Hunter Residency and Success. During RY98–RY02 the reported number of hunters increased while the reported number of moose killed remained stable (Table 2). Units 20C and 25C saw increases of 26% and 42% in the reported number of hunters during that 5-year period, while Unit 20F saw a decrease of 8% in the reported number of hunters. This change implies that hunter success declined significantly in Units 20C and 25C. However, this could be largely influenced by our recently increased efforts to get harvest reports from unsuccessful hunters.

During RY98–RY02, 3–6 nonresident hunters reported hunting in Unit 20F, even though the unit had no open moose season for nonresidents. Reported moose harvest by nonresidents in Unit 20F was 10% of the reported harvest in RY00. Unit 20F nonresident harvest data may be attributed to misreporting by nonresident hunters, data management errors by department staff, or legitimate harvest reports from nonresident hunters.

In Units 20C and 20F, most successful hunters resided in that unit. In Unit 25C, however, most successful hunters (92%) resided outside the unit, including residents and nonresidents of Alaska (Table 2). This difference can be attributed to 1) relatively few people reside in Unit 25C, 2) Unit 25C was road accessible and within 2 hours of the population center of Fairbanks, 3) motorized vehicle restrictions were uncommon in the area, and 4) it was one of the few road-system areas with a bag limit of any bull for residents and nonresidents.

Harvest Chronology. During RY98–RY02 the highest proportion of the harvest occurred during the second week of the season. In Units 20C and 20F, the first and third weeks shared similar proportions of the harvest (Table 4). Few moose were reported harvested during the December season in Unit 20F.

Transport Methods. In Unit 20C most successful hunters used boats, airplanes, and 3- or 4-wheelers for transportation (Table 5). Extensive river systems, many lakes, gravel bars, and an expanding trail system make these transport methods most useful. In Unit 20F boats were the primary mode of transportation for successful hunters, and in Unit 25C successful moose

hunters used highway vehicles, 3- or 4-wheelers, and boats. The transportation methods used throughout this area reflected access opportunities in the area.

HABITAT

Moose densities in areas like Units 20C, 20F, and 25C are typically limited by predation rather than forage (Gasaway et al. 1992), since predators kill a large majority of all calves produced on an annual basis. However, since forage resources determine moose calving rates, good habitat can boost moose numbers during lulls in predation caused by hunting or trapping pressure, disease, or chance. In remote country such as this, the most effective means of habitat improvement is wildfire. Some wildfires and prescribed burns have occurred in the area over the last 25 years, and a map of the burned areas is available from BLM. Some small-scale habitat improvements are being completed in the area. BLM is reclaiming mine tailings within the White Mountains National Recreation Area in Unit 25C. Native willows are being planted to enhance the revegetation process and increase moose browse.

NONREGULATORY MANAGEMENT PROBLEMS/NEEDS

Harvest reporting in these units was poor. We need to contact more people in remote areas to emphasize the importance and benefits of reporting harvest. It would be especially helpful to contact young people in village schools to establish harvest reporting as a responsibility of all hunters and to promote the positive aspects of reporting.

Fire is an integral part of Interior ecosystems and is essential to producing good moose habitat in areas of climax spruce forests. We should continue to coordinate wildlife needs with fire suppression activities and encourage more controlled burns to enhance habitat.

CONCLUSIONS AND RECOMMENDATIONS

Moose populations in Units 20C, 20F, and 25C are at low densities. Hunting pressure was relatively low, but increasing. We met our objective to maintain a bull:cow ratio of ≥30:100 and recommend that this objective be amended during the next reporting period to read as follows. Maintain a bull:cow ratio of ≥30:100 in areas with aerial surveys and ≥20% large bulls in the harvest in areas without aerial surveys.

No regulatory changes are recommended at this time. We estimated hunting and nonhunting mortality and worked to gather information on reporting rates from rural communities to produce a more comprehensive harvest estimate. We met our goal to promote natural fires to enhance moose habitat through the department's efforts on the Interagency Fire Management Team. We met our goal of providing for sustained harvest of these low-density populations.

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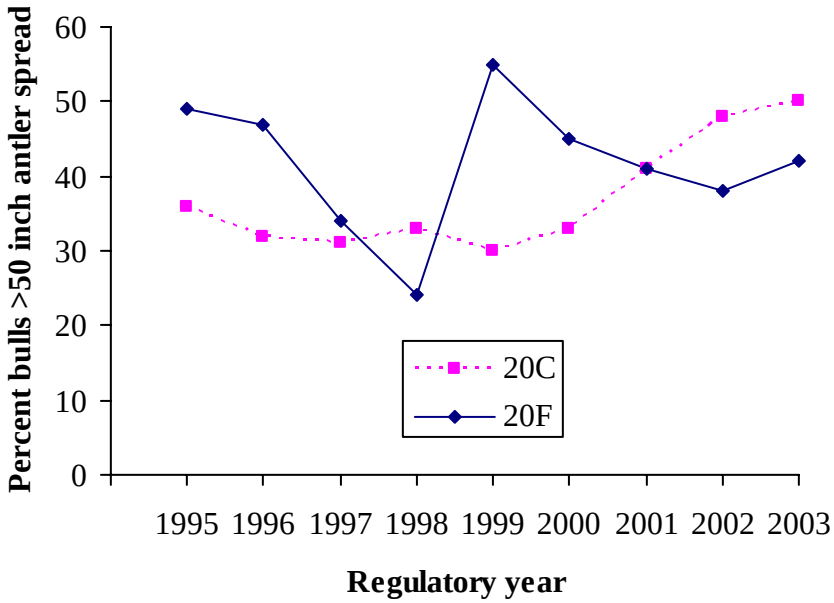

FIGURE 1 Percent of bull moose in the reported fall harvest with an antler spread >50 inches in Units 20C and 20F, regulatory years 1995–1996 through 2003–2004

TABLE 1 Unit 25C fall aerial moose composition counts, 1986–2002

Year	Bulls:100 Cows	Yearling bulls:100 Cows	Calves: 100 Cows	Calves	Percent calves	Adults	Moose observed	Moose/mi^2	Survey area size (mi^2)
1986[a]	103	13	21	8	9	77	85	1.49	57
1987[a]	77	11	28	13	14	83	96	1.68	57
1988[a]	129	37	33	16	13	112	128	2.25	57
1996[a]	119	19	11	3	5	57	60	1.05	57
1996[c]	160	0	20	2	7	26	28	0.31[d]	89[e]
1997[b]	53	13	37	80	20	319	399	0.46	5000
2002[a]	71	16	9	4	5	77	81	1.42	57
2002[c]	59	31	19	6	11	51	57	0.60[d]	95[e]

[a] O'Brien Creek count area.
[b] Geostatistical Population Estimator moose population estimate.
[c] Ophir Creek count area.
[d] Moose per linear mile along a route of flight over linear riparian habitat.
[e] Linear miles.

TABLE 2 Units 20C, 20F, and 25C reported moose hunter residency and success, regulatory years 1998–1999 through 2002–2003

Regulatory year	Successful hunters					Unsuccessful hunters					Total hunters
	Local[a] resident	Nonlocal resident	Nonresident	Total	(%)	Local[a] resident	Nonlocal resident	Nonresident	Total	(%)	
Unit 20C											
1998–1999	87	39	14	140	(35)	185	57	13	255	(65)	395
1999–2000	98	21	13	132	(32)	196	66	17	279	(68)	411
2000–2001	87	31	13	131	(28)	222	82	25	329	(72)	460
2001–2002	89	36	16	141	(31)	198	98	24	320	(69)	461
2002–2003	85	34	12	131	(26)	237	98	31	366	(74)	497
Unit 20F											
1998–1999	29	15	1	45	(29)	83	23	3	109	(71)	154
1999–2000	25	7	1	33	(25)	69	27	2	98	(75)	131
2000–2001	27	9	4	40	(24)	89	38	2	129	(76)	169
2001–2002	20	9	0	29	(20)	80	33	3	116	(80)	145
2002–2003	25	12	2	39	(28)	70	28	4	102	(72)	141
Unit 25C											
1998–1999	5	68	11	84	(34)	23	130	13	166	(66)	250
1999–2000	8	47	14	69	(26)	21	156	19	196	(74)	265
2000–2001	7	53	19	79	(24)	29	198	20	247	(76)	326
2001–2002	2	50	9	61	(19)	23	218	26	267	(81)	328
2002–2003	7	54	13	74	(21)	23	224	33	280	(79)	354

[a] Hunters who live within the unit in which they reported hunting were considered local.

TABLE 3 Estimate of Units 20C, 20F, and 25C moose harvest and accidental death, regulatory years 1998–1999 through 2002–2003

Regulatory year	Harvest by hunters							Accidental death			Total
	Reported[a]				Estimated						
	M	F	Unk	Total	Unreported[b]	Illegal/Other[c]	Total	Road[d]	Train[e]	Total	
Unit 20C											
1998–1999	140	0	0	140	25	1	26	0	3	3	169
1999–2000	125	0	0	125	22	0	22	0	21	21	168
2000–2001	130	0	0	130	23	0	23	0	0	0	153
2001–2002	142	0	0	142	25	0	25	0	1	1	168
2002–2003	131	0	0	131	23	0	23	0	0	0	154
Unit 20F											
1997–1998	29	0	0	29	5	1	6	1		1	36
1998–1999	45	0	0	45	8	1	9	0		0	54
1999–2000	33	0	0	33	6	2	8	1		1	42
2000–2001	40	0	0	40	7	0	7	0		0	47
2001–2002	29	0	0	29	5	1	6	0		0	35
2002–2003	40	0	0	40	7	1	8	0		0	48
Unit 25C											
1997–1998	57	0	0	57	10	0	10	0		0	67
1998–1999	85	0	0	85	15	0	15	3		3	103
1999–2000	66	0	0	66	11	0	11	0		0	77
2000–2001	79	0	0	79	14	1	15	0		0	94
2001–2002	62	0	0	62	11	0	11	0		0	73
2002–2003	75	0	0	75	13	2	15	0		0	90

[a] Data from ADF&G harvest reports.
[b] Based on 17.7% unreported harvest (including wounding loss) estimated by Gasaway et al. (1992).
[c] Data from Fairbanks Bureau of Wildlife Enforcement wildlife mortality logs and ADF&G records.
[d] Documented kills from Fairbanks Bureau of Wildlife Enforcement wildlife mortality logs.
[e] Confirmed dead between Alaska Railroad mileposts 327.0–370.9; "missing" (moose hit but not recovered) are not included. Data provided by the Alaska Railroad and summarized by ADF&G office in Palmer.

TABLE 4 Units 20C, 20F, and 25C reported moose harvest chronology by month/day, regulatory years 1998–1999 through 2002–2003[a]

Regulatory year	Harvest chronology by month/day				
	9/1–9/7	9/8–9/15	9/16–9/20	12/1–12/10	Total
Unit 20C					
1998–1999	35	54	42		131
1999–2000	35	52	39		126
2000–2001	41	48	36		125
2001–2002	28	58	49		135
2002–2003	33	61	31		125
Unit 20F					
1998–1999	11	25	6	3	45
1999–2000	5	18	4	5	32
2000–2001	10	21	5	4	40
2001–2002	5	13	9	1	28
2002–2003	9	21	8	1	39
Unit 25C					
1998–1999	35	47			82
1999–2000	31	37			68
2000–2001	28	50			78
2001–2002	22	36			58
2002–2003	18	55			73

[a] Does not include kills reported outside open hunting seasons.

TABLE 5 Units 20C, 20F, and 25C reported moose harvest percent by transport method, regulatory years 1998–1999 through 2002–2003

	Harvest percent by transport method								
Regulatory year	Airplane	Horse/Dogsled	Boat	3- or 4-wheeler	Snowmachine	Other ORV	Highway vehicle	Unk/Other	*n*
Unit 20C									
1998–1999	16	1	33	24	0	19	5	2	140
1999–2000	15	2	38	20	0	18	5	2	131
2000–2001	22	0	36	23	1	12	5	1	130
2001–2002	23	1	33	20	0	13	10	0	142
2002–2003	21	1	41	14	0	18	4	1	131
Unit 20F									
1998–1999	0	2	56	16	4	2	20	0	45
1999–2000	3	0	33	27	12	6	15	3	33
2000–2001	5	0	45	30	8	0	10	2	40
2001–2002	0	0	48	24	3	7	14	3	29
2002–2003	10	0	30	28	3	15	15	0	40
Unit 25C									
1998–1999	4	0	21	40	0	5	28	2	85
1999–2000	9	0	26	39	0	3	24	0	70
2000–2001	5	0	24	38	0	6	25	1	19
2001–2002	6	0	26	55	0	6	5	2	62
2002–2003	4	1	25	45	0	3	20	1	75

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MOOSE MANAGEMENT REPORT

From: 1 July 2001
To: 30 June 2003[a]

LOCATION

GAME MANAGEMENT UNIT: 20D (5637 mi^2)

GEOGRAPHIC DESCRIPTION: Central Tanana Valley near Delta Junction

BACKGROUND

Unit 20D was created in 1971 from a portion of Unit 20C. During 1962–1970, the moose hunting season in the area that is currently Unit 20D consisted of a 70–72 day bull season and a 1–8 day antlerless moose season. Most (51–74%) of the harvest during 1964–1970 came from the highly accessible areas near Delta Junction (Clearwater Lake, Donnelly Dome, and the Delta farming area). However, several severe winters in the mid 1960s and early 1970s killed many moose throughout this unit and other portions of Interior Alaska and set the stage for predation and hunting to compound and aggravate already widespread population declines. Poor recruitment of yearlings to the population in combination with intense bulls-only hunting depressed the bull:cow ratio to only 4:100 in the more accessible portions of the unit. The moose hunting season was closed during 1971–1973 because the depressed moose population could no longer support any significant harvest (McIlroy 1974).

Despite restrictions on hunting, the moose population in Unit 20D continued to decline because of chronically high moose mortality from other causes. In 1973 the moose population in the area south of the Tanana River and between the Johnson and Delta Rivers was estimated at only 600. When limited moose hunting was resumed in 1974, it was conducted under a registration permit system for the entire unit; however, an area around Delta Junction was closed to the taking of antlerless moose. The moose population decline in the western portion of the unit was gradually reversed by a combination of continued hunting restrictions, mild winters, and wolf control efforts in adjacent Unit 20A (1976–1982) and western Unit 20D (1980–1983).

In 1978 the unit was enlarged by moving the eastern boundary from the Johnson River to the Robertson River. It was further enlarged in 1981 to include all drainages north of the Tanana River from the mouth of the Robertson River to Banner Creek.

[a] This unit report also includes data collected outside the reporting period at the discretion of the reporting biologist.

In 1983 the closed area around Delta Junction, which had been established in 1974, was formally named the Delta Junction Management Area (DJMA). The name of the DJMA was changed to the Delta Junction Closed Area (DJCA) in 1990 to more accurately reflect its status as an area closed to hunting. In 1991 the DJCA was reduced in size to provide more hunting opportunity in the area. In 1996 the DJCA was renamed the DJMA, and a drawing permit hunt was established in the area.

Unit 20D has been subdivided into 4 areas for moose management purposes: southwestern Unit 20D, the area south of the Tanana River from the Johnson River to the Delta River; southeastern Unit 20D, the area south of the Tanana River from the Robertson River to the Johnson River; northwestern Unit 20D, the area north of the Tanana River from Banner Creek to and including the Volkmar River; and northeastern Unit 20D, the area north of the Tanana River and east of the Volkmar River.

As moose populations recovered during the mid 1970s and early 1980s, hunting opportunities were expanded in southwestern Unit 20D by first eliminating the registration permit requirement and then by lengthening the season. In southeastern and northern Unit 20D, the seasons were also increased. Antler restrictions were implemented in southwestern Unit 20D in 1988 to stabilize the increasing harvest and to improve the age structure in the bull segment of the population. In March 1995 the Alaska Board of Game determined that the preferred use of moose in Unit 20D was for human consumption and established a moose population objective of 8000–10,000 and an annual harvest objective of 240–500. The harvest objective was increased to 500–700 moose in 2000.

The Bison Range Youth Hunt Management Area was created in 2002 to regulate moose hunting in the fields of the Delta Junction Bison Range. This drawing permit hunt was implemented, in part, to reduce the impact of moose hunting on bison management on the Bison Range.

MANAGEMENT DIRECTION

MANAGEMENT OBJECTIVE

- Increase the fall moose population to 8000–10,000 moose with an annual reported sustainable harvest of 500–700 moose per year.

METHODS

Population Estimates: The Geostatistical Population Estimator (GSPE, Ver Hoef 2001) was used to conduct moose population estimates in Unit 20D. Guidelines recommended by Ver Hoef (ADF&G, personal communication) to maximize accuracy and precision of GSPE surveys were to allocate 60% of sampling effort to the high-density stratum and 40% of effort to the low-density stratum.

Sample units (SU) were stratified as having an anticipated high or low density of moose based on previous stratifications and existing knowledge of the area. In general, SUs were stratified low if I expected to count <5 moose in them. Sample units were stratified high if I expected to

count ≥5 moose in them. In an attempt to keep variance as small as possible, I placed borderline SUs in the high stratum to minimize variance in the low stratum.

GSPE SUs are square in shape and drawn with boundaries every 2 degrees of latitude on even increments and every 5 degrees of longitude on multiples of 5 degrees. Sample units varied in size from approximately 5.7 to 5.9 mi^2 in Unit 20D. Each SU is identified by the latitude and longitude of its southeast corner.

Sample unit selection was modified in 2001 from previous GSPE surveys to optimize the spatial sampling design by selecting adjacent pairs of SUs distributed evenly, rather than randomly, throughout the survey area.

The number of SUs to be surveyed in each stratum was divided by 2 to determine the number of SU pairs that would be sampled. Then the total number of SUs in each stratum was divided by the number of pairs to be sampled to determine how many SUs would be grouped together to be represented by 1 sampled pair. I grouped SUs with similar anticipated moose densities, habitat types, and topographic features.

For example, in 2001 funding was available to survey 24 SUs in the high-density stratum, which consisted of 119 SUs. The 24 SUs to be surveyed in the high stratum equaled 12 paired SUs. Therefore, a pair of SUs was allocated for approximately every 10 high density SUs. I then used a map of SUs to identify SU groups, averaging 10 SUs per group (range 8–12). The following SU groups were established with the number of SUs in each: Robertson River (9), Berry Creek (10), Knob Ridge (10), Johnson–Gerstle (11), Upper Sawmill Creek (8), Cummings Road (11), Jarvis Creek (11), Delta River (10), 12-mile Crossing (10), 33-mile Loop Road (9), 1408 Road (8), and Clearwater Lake (12). Once groups were identified, an adjacent pair of SUs was randomly selected from within each group to be sampled.

This process was repeated for the low-density stratum, which had 7 SU groups ranging from 23–27 SUs each. The following low density groups and their number of SUs were established as follows: Robertson River (23), Dot Lake (26), Independent Ridge (27), Gerstle River (25), Jarvis Creek (25), Delta Agricultural Project (25), and Delta Junction (25).

Sample units were surveyed with a Piper PA-18 Super Cub and a Robinson R-22 helicopter. Aerial surveys were flown at altitudes of approximately 300–800 ft above ground level, depending on vegetative cover. Flight speed was 60–70 mph in the PA–18 and 50–60 mph in the R-22. When terrain permitted, east–west linear transects were flown every 0.15 degrees of latitude, or north–south every 0.3 degrees of longitude. A global positioning system receiver (GPS) was used to follow transect headings. In hilly or mountainous terrain, the flight path followed terrain contours within SU boundaries, rather than transects. Our goal was to spend 8–10 min/mi^2 of search effort in each SU sampled to achieve consistently high sightability of moose. However, large areas of nonmoose habitat (i.e., lakes, areas covered with ice) within an SU were not surveyed.

We circled all moose seen, to look for additional moose and to classify moose as bulls, cows, or calves. Bulls were further classified into 5 categories based on antler size and morphology that included 1) yearlings with spike-fork antlers, 2) yearlings with nonspike-fork antlers,

3) medium bulls with antler spread of 31–40 inches, 4) medium bulls with antler spread 41–49 inches, and 5) large bulls with antler spread ≥50 inches. We estimated antler spread on all medium and large bulls. We identified yearling bulls as those with antler spread <30 inches and with no antler brow palm development.

Information recorded for each SU included 1) survey start and stop times, 2) snow and light conditions, 3) major habitat type, 4) location, and 5) survey rating of excellent to poor, based on the observer's general impression.

Sample unit data were entered into a Microsoft®Excel spreadsheet and analyzed with S-PLUS 2000 software (Mathsoft, Seattle, WA, spatial statistics model) using the GSPE.

Once 5 population estimates had been calculated for southern Unit 20D from 1995 to 2003, the estimates were "smoothed" by using parametric empirical Bayes (PEB) methods (Ver Hoef 1996). PEB methods use 2 sources of variation with 1 being variation of replicate counts of SUs (i.e., sampling variance) and the other being variation around the population trend line among years (i.e., regression variance). The PEB method borrows strength from multiple surveys to fit the individual yearly estimates closer to the population trend line. Therefore, previous population estimates reported for southern Unit 20D will vary from the "smoothed" estimates calculated for this report and in the future. Also, the PEB method allows for population estimates to be calculated from the trend line for those years that surveys were not conducted. Population composition ratios were calculated from unsmoothed data.

Additional moose survey funds became available after completion of the 2001 GSPE survey and southern Unit 20D was stratified from 24 November–12 December using a Piper PA–18 Super Cub. The stratification was conducted using GSPE SUs. We stratified by flying east–west transects through the midpoint of each SU. The proportion of habitat in each SU was estimated and classified as low shrub (generally *Salix* species), tall shrub, deciduous forest, sparse spruce forest, spruce forest, or nonmoose habitat. The presence of moose tracks and number of moose seen in the SU were recorded. Before exiting the SU, it was stratified as either high or low density.

Twinning Surveys. Surveys were flown in a Piper PA–18 at an altitude of 300–700 feet above ground level and at an airspeed of approximately 70 mph by flying linear transects spaced approximately 0.5 miles apart. The survey objective was to observe a sample of 50 cows with calves. Large areas where there was little chance of spotting a moose (i.e., large agricultural grain fields, areas of dense spruce) were not surveyed.

Sample units were drawn on 1:63,360 scale U.S. Geological Survey topographic maps using topographic features as boundaries. The Sawmill Creek South SU was not flown in 2003 because it had been unproductive in previous years and the Jarvis Creek West SU was not flown because of its close proximity and partial overlap with the newly developed National Missile Defense Bed on Fort Greely Military Reservation. Some SU boundaries are still evolving to maximize efficiency. The Big Lake SU was reduced in size to approximately 19.8 mi^2 for 2003 to eliminate area that had few moose in past years. To compensate for the reduction of these SUs, the Butch Lake SU was expanded to approximately 17.7 mi^2 and the Granite–Rhodes Creek SU was expanded to approximately 12.0 mi^2. The Sawmill Creek

North (16.2 mi^2), Delta Ag Project East and Delta Ag Project West (156.0 mi^2), and Clearwater (13.0 mi^2) SUs were unchanged. In addition to surveying the SUs listed above, moose we observed while flying en route to SUs were also classified and recorded.

When moose were spotted, a low pass was made to determine the sex and to look for calves with cow moose. Moose ≥1 year old with visible antlers were classified as bulls; all others were classified as cows. If no calves were observed with cows, 2–4 additional low passes were made over the cow to improve sightability. Data recorded for each observation included the sex of the moose, the presence or absence of calves or yearling offspring, and the moose location.

Harvest Monitoring. Harvest of moose by hunters during the general hunting seasons was monitored by requiring hunters to acquire moose harvest tickets and report hunting activities that included: the location hunted, how long they hunted, their mode of transportation, whether they killed a moose, where and when they killed a moose, the antler spread and number of brow tines on moose killed, and the type of weapon used to kill the moose. Hunters who participated in permit hunts provided the same information via permit report forms. Harvest data were summarized by regulatory year (RY), which begins 1 July and ends 30 June (e.g., RY01 = 1 Jul 2001–30 Jun 2002). Reminder letters were sent to holders of harvest tickets and permits to increase reporting rate.

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

2001

A GSPE survey was flown during 4–23 November 2001 in southern Unit 20D for approximately $10,880. I estimated 3435 moose (2643–4227) at the 90% confidence interval (Table 1). Average SU search time was 46.0 minutes (7.9 min/mi^2) in the high-density stratum and 38.7 minutes (6.7 min/mi^2) in the low-density stratum. Therefore, the search effort goal was essentially met in the high density, but effort was below the goal in the low density.

The 2001 southern Unit 20D population estimate was combined with the 1999 northern Unit 20D population estimate to calculate a new Unit 20D total population estimate of 5830 moose (4956–6704). An assumption in this calculation is that the northern Unit 20D population estimate had not changed significantly since 1999. This population estimate did not meet the Unit 20D moose population goal established by the Board of Game.

Twinning surveys were flown on 29 and 31 May, and 1, 2, and 4 June 2001 for 12.6 h of survey time for $2700. Most flights began in the evening from 1815 hours to 2100 hours and concluded from 2224 hours to 2335 hours. One morning flight was conducted from 0555 to 0807 hours. Two hundred eighty-two moose were seen at the rate of 22.4 moose/h of survey time. Forty-seven cow-calf groups were seen with 7 (15%) being cows with twins.

The southern Unit 20D stratification survey occurred from 24 November to 12 December. One hundred eighty-six SUs were stratified as high density and 134 were stratified as low density.

2002

No population estimate was conducted in Unit 20D because of poor survey conditions during the entire survey period.

Twinning surveys were flown on 25, 27, 28, and 29 May 2002 for a total of 11.9 h of survey time and a cost of $2520. Flights began in the morning from 0610 to 0640 hours and concluded from 0800 to 1215 hours. Moose were seen at the rate of 22.5 moose/h and 268 total moose were seen. Sixty-one cow-calf groups were seen with 13 (21%) being cows with twins.

2003

A GPSE survey was flown in southern Unit 20D from 11–18 November 2003 for approximately $11,355. The population estimate was 5493 moose (3924–7061) at the 90% confidence interval (Table 1). The smoothed estimate was 4456 (3752–5209, Table 2). Average SU search time was 44.4 minutes (7.7 min/mi^2) in the high density and 41.5 minutes (7.2 min/mi^2) in the low-density stratum. The 2003 southern Unit 20D was not combined with the 1999 northern Unit 20D to calculate a unit estimate because the time interval between the surveys was considered too long.

Twinning surveys were flown on 25, 28, and 29 May 2003 for a total of 11.3 h of survey time and a cost of $2700. Surveys began in the morning from 0608 to 0709 hours and were completed by 1117 hours. Moose were seen at the rate of 24.2 moose/h with 273 moose observed. Fifty-one cow-calf groups were observed with 10 (20%) being cows with twins.

Population Composition

2001. Southern Unit 20D population composition from the fall 2001 GSPE survey was 16 bulls:100 cows (range = 10–22) and 24 calves:100 cows (range = 16–32, Table 1). This is the lowest bull:cow ratio recorded in southern Unit 20D since population estimates began in the area.

2002. No composition data was collected during 2002 due to poor survey conditions.

2003. Southern Unit 20D population composition from the fall 2003 GSPE survey was 23 bulls:100 cows (range = 19–26) and 32 calves:100 cows (range = 27–37, Table 1).

Distribution and Movements

No data were collected on moose distribution or movements during this reporting period.

MORTALITY

Harvest

Season and Bag Limit. Hunting seasons and bag limits are listed in Table 3.

Alaska Board of Game Actions and Emergency Orders.

2002 — At the March 2002 Alaska Board of Game meeting there were 5 proposals pertaining to moose regulations in Unit 20D. Proposal 4 was adopted by the board and created the Bison Range Youth Hunt Management Area on a portion of the Delta Junction Bison Range. The purpose of the proposal was to allow the department to better meet bison management objectives by regulating moose hunting. Proposal 5 was adopted to increase the number of drawing permits authorized for the DJMA from 10 to 30. Proposal 6 was adopted and created a nonresident moose hunting season in the upper Robertson River drainage. This area had previously been closed to nonresident moose hunters because of customary and traditional use considerations in southeastern Unit 20D. Proposal 7 to change the brow tine restriction in southwestern Unit 20D from 4 to 3 brow tines was not adopted. Proposal 12 to create a controlled use area in northern Unit 20D to regulate the use of airboats was not adopted.

2004 — At the February 2004 meeting, the board adopted regulation proposal 109 to eliminate the Tier II moose hunt TM787 in Unit 20D. The proposal was submitted by the department because overall interest and participation in the hunt was declining by local residents and it had a very low harvest. The board adopted proposal 110 submitted by the Delta Bison Working Group and the Delta Fish and Game Advisory Committee to change moose hunting regulations in the Bison Range Youth Hunt Management Area. The proposal was developed from recommendations by the Bison Range Youth Hunt Ad Hoc Committee to address public concerns about the hunt. The proposal changed the bag limit to 1 bull per lifetime with spike-fork antlers or antlers at least 50-inches wide or with at least 4 brow tines on 1 side and restricted motorized vehicles for all hunting. Proposal 111 was submitted by the president of the Dot Lake Village Council to align the moose hunting seasons between eastern Unit 20D and 12, to close the hunting season in eastern Unit 20D during 1–7 September, and to eliminate the Tier II hunt TM787 in southeastern Unit 20D. The proposal was not adopted. The board adopted proposal 112, submitted by the Healy Lake Traditional Council, to eliminate the 1 January–15 February hunt for 1 bull within the Healy River drainage. The justification was to eliminate problems with trespassing on Native lands and interference with traplines by hunters. Proposal 113 was submitted by a member of the public to establish a drawing permit hunt for 10 cow moose within the Delta Junction Management Area. The justification was to reduce the number of moose within the Delta Junction Management Area. The proposal was not adopted.

Human-Induced Mortality

RY01. Estimated moose mortality from all human causes was 263 (Table 4). This includes 182 moose reported killed by hunters during the hunting season, an estimated 32 moose harvested but not reported, 17 moose reported by Alaska Bureau of Wildlife Enforcement (ABWE) to have been killed illegally, and 32 road kills reported by ABWE. Most illegal kills and road kills occurred in southwestern Unit 20D. The total reported hunting kill of 182 was well below the harvest objective of 500–700. The reported hunting harvest was 4.6% of the

smoothed population estimate. Total human-induced mortality was 6.7% of the smoothed population estimate.

RY02. Estimated moose mortality from all human causes in Unit 20D was 274 moose (Table 4). This included 228 moose reported killed by hunters, an estimated 40 unreported hunter kills, and an illegal harvest of 6 moose reported by ABWE. The number of moose killed on the road system was not available for this report. The total reported hunting harvest of 228 moose did not meet the harvest objective of 500–700 moose. The reported hunting harvest was 5.4% of the smoothed population estimate. Total known human-induced mortality was 6.5% of the smoothed population estimate.

RY03. Estimated moose mortality from all human causes increased during RY03 to 267 moose (Table 4). This included 227 moose reported killed by hunters during the hunting season and an estimated unreported harvest of 40 moose. Information on moose road kills and illegal harvest was not available for this report. The total reported hunting mortality of 227 was below the harvest objective of 500–700. The reported hunting harvest was 5.4% of the smoothed population estimate. Total known human-induced mortality was 6.1% of the smoothed population estimate.

Southwestern Unit 20D Hunter Harvest. Southwestern Unit 20D has the highest harvest in the unit. Reported hunter harvest during RY01 was 105 moose, with 101 taken during the general season (Table 5) and 4 taken during permit hunt DM790 in the DJMA (Table 6). During the general season, 425 hunters killed 101 moose (Table 5) for a 24% success rate. Hunters who participated had a 50% success rate during hunt DM790.

Reported hunter harvest during RY02 was 142 moose, with 119 killed during the general hunting season (Table 5), 6 killed during hunt DM790 (Table 6) and 17 killed during hunt DM792 (Table 7). During the general season, 426 hunters killed 119 moose (Table 5) for a 28% success rate. Hunters who possessed DM790 permits and hunted had a 60% success rate and DM792 hunters who hunted had a 71% success rate.

Reported hunter harvest during RY03 was 137 moose, with 124 killed during the general hunting season (Table 5), 6 killed during hunt DM790 (Table 6) and 7 killed during hunt DM792 (Table 7). During the general season, 447 hunters killed 124 moose (Table 5) for a 28% success rate. This is the largest number of hunters who reported since at least RY84. Southwestern Unit 20D has the most restrictive hunting regulations in the unit in the form of antler restrictions, yet moose harvest and number of hunters has continued to increase since the regulations were implemented. The increase is likely due to increased numbers of moose and good access in the area. Hunters that participated in hunt DM790 had a 75% success rate and DM792 hunters had a 37% success rate for DM792.

Southeastern Unit 20D Hunter Harvest. Moose harvest remained low in southeastern Unit 20D. During the general seasons, only 10–17 moose were killed annually during RY01–RY03 (Table 5). Hunter success rates varied from 32–44% during this period. Tier II hunt TM787 had 0–2 moose killed (Table 8). Harvest during the general hunting season was low in this area primarily because of motorized access restrictions in the Macomb Plateau Controlled Use Area, which made moose hunting difficult.

Northwestern Unit 20D Hunter Harvest. Northwestern Unit 20D has the second highest harvest in the unit. During the RY01 general season, 52 moose were killed by 221 hunters (Table 5) for a 24% success rate. During the RY02 general season, 56 moose were killed by 281 hunters (Table 5) for a 20% success rate. During the RY03 general season, 53 moose were killed by 230 hunters (Table 5) for a 23% success rate. There were no permit hunts in northwestern Unit 20D.

Northeastern Unit 20D. The number of hunters and harvest remained low in northeastern Unit 20D during the RY01–RY03 general season. Harvest ranged from only 5 to 14 moose, with the number of hunters ranging from 39 to 41, and success rates ranging from 13 to 45% (Table 5). This area is difficult to access during the hunting season except along the Tanana River, along a few small creeks and rivers flowing into the Tanana River, and at a few ridgetop airstrips.

Moose hunters did not appear to take advantage of the August and January–February moose hunting seasons in the Healy River drainage during RY01–RY03. During this reporting period, no moose were reported killed during the August season, and only 1 moose was reported killed during the January–February season when a hunter from Wasilla, Alaska killed a bull on 25 January 2003. The general season harvest in the Healy River drainage (Uniform Coding Unit 501) ranged from 1–5 moose during RY01–RY03 (Table 9).

Hunter Residency. The proportion of local hunters (residing in Unit 20D) has been decreasing since the mid 1980s (Table 10). In 1986–1987, 59% of Unit 20D hunters were local residents. That proportion was fairly stable during the 1990s ranging from 48 to 55%. However, the proportion of local hunters declined to a low of 39% in RY01. Local hunters increased in RY02–RY03 with 72% and 66% respectively (Table 10). The proportion of nonresident hunters was low with 7% in RY01, 6% in RY02, and 5% in RY03.

Hunter Effort. Mean days hunted by all hunters during RY01–RY03 was very similar to the previous 5 years (Table 11).

Permit Hunts. Tier II permit hunt number TM787 was conducted during 1 January–15 February of RY01–RY03. Fifteen permits were issued annually, with a harvest quota of 5 bulls. Participation in the hunt varied with 27–67% of permittees hunting during RY01–RY03. No moose were killed in RY01, 1 moose was killed in RY02, and 2 were killed in RY03 (Table 8).

Permit hunt DM790 (Delta Junction Management Area) had 10 drawing permits issued each year during RY01–RY03. Participation by permit recipients was generally high with 80–100% of recipients hunting. Four moose were killed in RY01, 6 were killed in RY02, and 6 were killed in RY03 (Table 6).

Permit hunt DM792 (Bison Range Youth Hunt Management Area) had 24 permits issued in RY02 and RY03. Participation was high; all recipients hunted in RY02 and 79% hunted in RY03. Seventeen moose were killed in RY02, but harvest decreased to 7 moose in RY03 (Table 7).

Harvest Chronology. During this reporting period, general season harvest chronology remained similar to previous years, with most harvest occurring during the first 5 days of the 15-day general season (Table 12).

Transport Methods. During this reporting period, 3- or 4-wheelers, highway vehicles, and boats continued to be the most common modes of transportation used by successful hunters (Table 13).

Natural Mortality

No estimates of natural mortality were calculated during this reporting period. However, predation by wolves, grizzly bears, and black bears is believed to be significant in Unit 20D. Predation is thought to limit moose population growth in the northern half of Unit 20D and account for reduced calf survival in portions of southern Unit 20D.

HABITAT

Assessment

No moose habitat assessment was conducted during this reporting period.

Enhancement

During RY01–RY03 no habitat enhancement projects were conducted.

CONCLUSIONS AND RECOMMENDATIONS

Population estimates were completed in southern Unit 20D, and results indicated the moose population did not meet the objective established by the Board of Game but was increasing. Smoothed population estimates indicate a lower population than estimated earlier. Unitwide harvest of moose was well below the objective established by the board.

The bull:cow ratio in southern Unit 20D appears to be stable or declining slightly. This situation should be monitored closely in the future and may require further harvest restrictions of bulls if the ratio gets lower.

Participation in the Tier II permit hunt in southeastern Unit 20D continued to be low, with few moose harvested. Because of this, the board eliminated the hunt at its 2004 meeting. Extra hunting seasons in the Healy River drainage did not appear to be used, and the board eliminated the January–February season at its 2004 meeting.

The unitwide population objective needs to be subdivided, as a minimum, into northern and southern Unit 20D objectives. The unitwide population objective of 8000–10,000 moose does not account for differences in moose density, habitat quality, harvest rates, predation rates, and other factors that are substantially different between these areas. Much of southern Unit 20D is road accessible and can and does support $\geq$ 2 moose/mi^2 because of manipulated predator populations through hunting and trapping and excellent habitat created through agricultural land clearing and wildfire. However, it will be very challenging to achieve and maintain 1 moose/mi^2 over large areas in the more remote northern Unit 20D given the lower quality habitat and reduced take of predators, even though habitat quality will improve greatly

given the extent of wildfires in this area in 2004. No large areas of remote, roadless Interior Alaska currently support moose densities of ≥ 1 moose/mi^2 because unmanipulated or slightly manipulated levels of bear and wolf predation limit moose below 1 moose/mi^2.

Southern Unit 20D and northern Unit 20D contain approximately 1890 mi^2 and 3138 mi^2 of moose habitat respectively. Therefore, without predator control programs, southern Unit 20D could support 2–3 moose/mi^2 totaling 3780–5670 moose. Northern Unit 20D could support 1 moose/mi^2 totaling 3138 moose. Therefore, with the current management programs in Unit 20D, the moose population can be expected to expand to approximately 6918–8808 moose, the upper limit of which would reach the Board of Game's population objective. Interior Alaska data indicate that additional intensive management practices, such as predator control, would be required to achieve a higher population objective.

It is likely that the number of moose in southwestern Unit 20D may reach maximum sustainable numbers before the Unit 20D population objective is achieved. In that case, it may be necessary to implement management actions to stabilize the population in southwest Unit 20D before the unit's population objective is reached.

I believe that it will also be difficult to achieve the harvest objective without harvesting cow moose. The bull:cow ratio in southern Unit 20D is currently low enough that achieving the harvest objective with a bulls-only bag limit would likely further reduce the bull:cow ratio to unacceptable levels. Also, the majority of harvest is currently coming from southwestern Unit 20D. It will be unrealistic to expect southwestern Unit 20D to provide the majority of harvest necessary to meet the harvest objective. Instead, additional harvest needs to be spread over portions of the unit that currently have low harvest rates. These are largely remote areas where access is difficult and expensive and bull:cow ratios are relatively high.

In conclusion, I believe the low end of the current Unit 20D population objective of 8000–10,000 moose is potentially achievable with the current management program. However, I do not believe the harvest objective of 500–700 is achievable without spreading a larger proportion of the harvest among northern and southeastern Unit 20D and initiating antlerless hunts in southwestern Unit 20D.

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TABLE 1 Results of population estimates for southern Unit 20D using a Gasaway[a] Method survey (GAS) and "unsmoothed" Geostatistical Population Estimator (GSPE) surveys, 1995–2003

Parameter	1995 GAS	1998 GAS	1998 GSPE	2000 GSPE	2001 GSPE	2003 GSPE
Total pop est.	2522	4050	3630	3932	3435	5493
LCI	1979	2826	2533	3245	2643	3924
UCI	3065	5275	4727	4618	4227	7061
Total calves	552	937	863	676	575	1097
LCI	411	682	630	498	453	830
UCI	693	1191	1097	855	697	1364
Total cows	1626	2580	2321	2530	2424	3476
LCI	1271	1741	1570	2021	1840	2363
UCI	1981	3418	3072	3039	3009	4588
Total bulls	343	530	479	671	392	790
LCI	249	350	305	530	281	462
UCI	437	710	653	813	504	1118
Bulls:100 Cows	21	21	21	27	16	23
LCI	17	16	16	19	10	19
UCI	25	25	25	34	22	26
Calves:100 Cows	34	36	37	27	24	32
LCI	29	32	32	22	16	27
UCI	39	41	42	31	32	37

[a] Gasaway et al. (1986).

TABLE 2 "Smoothed" moose population estimates for southern Unit 20D, 1995–2003

Year[a]	Estimate	90% Lower CI	90% Upper CI
1995	**2507**	**2037**	**2938**
1996	2751	2298	3170
1997	2992	2638	3379
1998	**3242**	**2917**	**3639**
1999	3462	3072	3854
2000	**3719**	**3324**	**4119**
2001	**3920**	**3378**	**4399**
2002	4195	3574	4838
2003	**4456**	**3752**	**5209**

[a] Years in bold text are years surveys were flown. Other years were estimated from the population trend line.

TABLE 3 Unit 20D moose hunting seasons and bag limits, regulatory years 2001–2002 through 2003–2004

Regulatory year	Area	Season		Bag limit
2001–2002	South of Tanana River and west of Johnson River, except Delta Junction Management Area.	Resident:	1–15 Sep	1 bull with spike-fork or 50-inch antlers or 4 or more brow tines on at least 1 side.
		Nonresident:	5–15 Sep	1 bull with 50-inch antlers[a].
	Within Delta Junction Management Area.	Resident:	1–15 Sep	1 bull with spike-fork or 50-inch antlers or 4 or more brow tines by drawing permits.
		Nonresident:	5–15 Sep	1 bull with 50-inch antlers[a] by drawing permit DM790.
	South of Tanana River and east of Johnson River.	Resident:	1–15 Sep	1 bull.
			1 Jan–15 Feb	1 bull by Tier II permit TM787.
		Nonresident:	No open season	
	Within the Healy River drainage.	Resident:	15–28 Aug	1 bull with spike-fork antlers.
			1–15 Sep	1 bull.
			1 Jan–15 Feb	1 bull.
		Nonresident:	1–15 Sep	1 bull.
	Remainder of Unit 20D (north of Tanana River).	Resident:	1–15 Sep	1 bull.
		Nonresident:	1–15 Sep	1 bull.
2002–2003 and 2003–2004	South of Tanana River and west of Johnson River, except Delta Junction Management Area and the Bison Range Youth Hunt Management Area.	Resident:	1–15 Sep	1 bull with spike-fork or 50-inch antlers or 4 or more brow tines on at least 1 side.
		Nonresident:	5–15 Sep	1 bull with 50-inch antlers[a].
	Within Delta Junction Management Area.	Resident:	1–15 Sep	1 bull with spike-fork or 50-inch antlers or 4 or more brow tines by drawing permits DM790.
		Nonresident:	5–15 Sep	1 bull with 50-inch antlers[a] by drawing permit DM790.
	Within the Bison Range Youth Hunt Management Area.	Resident	1–30 Sep	1 bull by permit DM792.
		Nonresident	1–30 Sep	1 bull by permit DM792.

Regulatory year	Area	Season		Bag limit
	South of Tanana River and east of Johnson River except within the Robertson River drainage south of the confluence of east and west fork, and within 1 mile west of the west fork.	Resident:	1–15 Sep	1 bull.
			1 Jan–15 Feb	1 bull by Tier II permit TM787.
		Nonresident:	No open season	
	Within the Robertson River drainage south of the confluence of east and west forks, and within 1 mile of the west fork.	Resident	1–15 Sep	1 bull.
			1 Jan–15 Feb	
		Nonresident	5–15 Sep	1 bull with 50-inch antlers, or at least 4 brow tines on at least 1 side.
	Within the Healy River drainage.	Resident:	15–28 Aug	1 bull with spike-fork antlers.
			1–15 Sep	1 bull.
			1 Jan–15 Feb	1 bull.
		Nonresident:	1–15 Sep	1 bull.
	Remainder of Unit 20D (north of Tanana River).	Resident:	1–15 Sep	1 bull.
		Nonresident:	1–15 Sep	1 bull.

[a] 50-inch antlers defined as having a spread of at least 50 inches or at least 4 brow tines on at least 1 side.

TABLE 4 Unit 20D moose harvest and accidental death, regulatory years 1986–1987 through 2003–2004

Regulatory year	Harvest by hunters							Accidental death			Total
	Reported				Estimated						
	M	F	Unk	Total	Unreported[a]	Illegal	Total	Road	Train[b]	Total	
1986–1987	130	0	0	130	23	4	27	15	0	15	172
1987–1988	126	0	0	126	22	10	32	26	0	26	184
1988–1989	126	0	0	126	22	13	35	27	0	27	188
1989–1990	128	0	0	128	23	9	32	16	0	16	176
1990–1991	118	1	0	119	21	4	25	11	0	11	155
1991–1992	143	1	0	144	25	11	36	13	0	13	193
1992–1993	143	0	1	144	25	5	30	32	0	32	206
1993–1994	154	0	1	155	27	14	41	30	0	30	226
1994–1995	128	0	0	128	23	7	30	31	0	31	189
1995–1996	138	0	0	138	24	20	44	25	0	25	207
1996–1997	214	0	0	214	38	22	60	39	0	39	313
1997–1998	210	0	0	210	37	15	52	48	0	48	310
1998–1999	234	0	0	234	41	11	52	31	0	31	317
1999–2000	184	0	0	184	33	7	40	40	0	40	264
2000–2001	246	0	0	246	44	20	64	37	0	37	347
2001–2002	182	0	0	182	32	17	49	32	0	32	263
2002–2003	228	0	0	228	40	6	46	n/a	0	n/a	274
2003–2004	227	0	0	227	40	n/a	40	n/a	0	n/a	267

[a] Based on 17.7% unreported harvest estimated by Gasaway et al. (1992).
[b] Not applicable in Unit 20D.

TABLE 5 Southwestern (SW), southeastern (SE), northwestern (NW), and northeastern (NE) Unit 20D reported moose harvest and number of hunters during general seasons, regulatory years 1984–1985 through 2003–2004

Regulatory	Moose harvest						Hunters					
year	SW	SE	NW	NE	Unk	Total	SW	SE	NW	NE	Unk	Total
1984–1985	39[a]	9[b]	40[c]	14[c]	0	102	236[a]	47[b]	294[c]	48[c]	10	635
1985–1986	48[d]	8[b]	60[d]	14[d]	0	130	236[d]	37[b]	272[d]	50[d]	9	604
1986–1987	76[d]	10[b]	40[d]	10[d]	1	137	250[d]	45[b]	232[d]	57[d]	12	596
1987–1988	66[d]	8[b]	43[d]	9[d]	0	126	296[d]	35[b]	208[d]	35[d]	17	591
1988–1989	60[e]	12[b]	39[d]	12[d]	3	126	244[e]	45[b]	201[d]	37[d]	28	555
1989–1990	60[e]	11[b]	41[d]	10[d]	5	127	303[e]	47[b]	191[d]	39[d]	40	620
1990–1991	58[f]	9[c]	40[g]	7[d]	4	118	270[f]	29[c]	195[g]	26[d]	28	548
1991–1992	54[f]	12[c]	66[g]	9[d]	3	144	331[f]	51[c]	231[g]	26[d]	19	658
1992–1993	59[f]	12[c]	58[g]	5[d]	9	143	329[f]	49[c]	257[g]	34[d]	48	717
1993–1994	74[h]	9[c]	58[c]	11[c]	2	154	324	33[c]	259[c]	29[c]	47	692
1994–1995	61[h]	7[c]	49[c]	9[c]	2	128	339	42[c]	267[c]	33[c]	28	709
1995–1996	60[h]	14[c]	50[c]	12[c]	2	138	301	32[c]	237[c]	42[c]	33	645
1996–1997	103[h]	13[c]	74[c]	16[c]	5	211	320	40[c]	267[c]	35[c]	31	693
1997–1998	88[h]	13[c]	72[c]	19[c]	10	202	325[h]	38[c]	241[c]	46[c]	33	683
1998–1999	122[h]	17[c]	64[c]	16[i]	8	227	431[h]	43[c]	231[c]	43[i]	47	795
1999–2000	107[h]	12[c]	42[c]	12[i]	4	177	358[h]	43[c]	177[c]	29[i]	37	644
2000–2001	140[h]	12[c]	65[c]	18[i]	5	240	355[h]	41[c]	194[c]	35[i]	32	657
2001–2002	101[h]	10[c]	52[c]	14[i]	1	178	425[h]	31[c]	221[c]	41[i]	26	744
2002–2003	119[h]	17[c]	56[c]	5[i]	7	204	426[h]	39[c]	281[c]	39[i]	51	836
2003–2004	124[h]	16[c]	53[c]	13[i]	6	212	447[h]	40[c]	230[c]	41[i]	36	794

[a] Season 1–6 Sep; 1 bull.
[b] Season 1–20 Sep; 1 bull.
[c] Season 1–15 Sep; 1 bull.
[d] Season 1–10 Sep; 1 bull.
[e] Season 1–15 Sep; 1 bull with spike-fork or 50-inch antlers or 3 brow tines on 1 antler.
[f] Subsistence–resident season 1–15 Sep; 1 bull with spike-fork or 50-inch antlers or 3 brow tines on 1 antler. Nonresident season 5–15 Sep; 1 bull with 50-inch antlers or 3 brow tines on 1 antler.
[g] West of pipeline season 1–15 Sep; 1 bull. Nonresident season 5–15 Sep; 1 bull with 50-inch antlers or 3 brow tines on 1 side. Remainder area 1–10 Sep; 1 bull.
[h] Resident season 1–15 Sep; 1 bull with spike-fork or 50-inch antlers or 4 brow tines on 1 antler. Nonresident season 5–15 Sep; 1 bull with 50-inch antlers or 4 brow tines on 1 antler.
[i] Resident season within 1–15 Sep; 1 bull. Within Healy River drainage: resident season 15–18 Aug, 1 bull with spike-fork antlers; 1–15 Sep, 1 bull; 1 Jan–15 Feb, 1 bull; nonresident season, 1–15 Sep; 1 bull. Remainder area is resident and nonresident 1–15 Sep, 1 bull.

TABLE 6 Unit 20D Delta Junction Management Area moose drawing permit harvest, regulatory years 1996–1997 through 2003–2004

Hunt	Regulatory year	Permits issued	Did not hunt (%)	Unsuccessful hunters (%)	Successful hunters (%)	Percent bulls	Percent cows	Unk	Harvest
DM790	1996–1997	5	0	40	60	100	0	0	3
DM790	1997–1998	10	20	0	80	100	0	0	8
DM790	1998–1999	10	0	0	100	100	0	0	10
DM790	1999–2000	10	0	30	70	100	0	0	7
DM790	2000–2001	10	20	20	60	100	0	0	6
DM790	2001–2002	10	20	40	40	100	0	0	4
DM790	2002–2003	10	0	40	60	100	0	0	6
DM790	2003–2004	10	20	20	60	100	0	0	6

TABLE 7 Unit 20D Bison Range Youth Hunt Management Area moose drawing permit harvest, regulatory years 2002–2003 through 2003–2004

Hunt/ Area	Regulatory year	Permits issued	Did not hunt (%)	Unsuccessful hunters (%)	Successful hunters (%)	Percent bulls	Percent cows	Unk	Harvest
DM792	2002–2003	24	0	29	71	100	0	0	17
DM792	2003–2004	24	21	50	29	100	0	0	7

TABLE 8 Unit 20D moose Tier II permit harvest, regulatory years 1989–1990 through 2003–2004

Hunt number	Regulatory year	Permits issued	Did not hunt (%)	Unsuccessful hunters (%)	Successful hunters (%)	Percent bulls	Percent cows	Unk	Harvest
988	1989–1990	15	27	91	9	100	0	0	1
987T	1990–1991	15	20	86	14	100	0	0	1
987T	1991–1992	15	67	100	0	0	0	0	0
987T	1992–1993	15	20	91	9	100	0	0	1
787	1993–1994	15	47	100	0	0	0	0	0
787	1994–1995	15	27	91	9	100	0	0	1
TM787	1995–1996	15	47	100	0	0	0	0	0
TM787	1996–1997	15	53	86	14	100	0	0	1
TM787	1997–1998	15	73	100	0	0	0	0	0
TM787	1998–1999	15	67	100	0	0	0	0	0
TM787	1999–2000	15	47	53	0	0	0	0	0
TM787	2000–2001	15	60	100	0	0	0	0	0
TM787	2001–2002	15	73	100	0	0	0	0	0
TM787	2002–2003	15	33	90	10	100	0	0	1
TM787	2003–2004	15	40	78	22	100	0	0	2

TABLE 9 Unit 20D Healy River (Uniform Coding Unit 501) reported moose harvest, regulatory years 1993–1994 through 2003–2004

Regulatory year	Unit 20D Healy River	
	Hunters	Harvest
1993–1994[a]	9	2
1994–1995[a]	13	2
1995–1996[a]	24	2
1996–1997[a]	10	2
1997–1998[a]	14	3
1998–1999[b]	19	5
1999–2000[b]	21	7
2000–2001[b]	24	6
2001–2002[b]	23	5
2002–2003[b]	10	1
2003–2004[b]	10	5

[a] Resident moose hunting season 1–15 Sep, 1 bull.
[b] Resident moose hunting season: 15–28 Aug, 1 spike-fork bull; 1–15 Sep, 1 bull; 1 Jan–15 Feb, 1 bull.

TABLE 10 Unit 20D moose hunter residency and success[a], regulatory years 1986–1987 through 2003–2004

Regulatory year	Successful						Unsuccessful						Total hunters
	Local[b] resident	Nonlocal resident	Nonresident	Unk	Total	(%)	Local[b] resident	Nonlocal resident	Nonresident	Unk	Total	(%)	
1986–1987	83	51	1	2	137	(23)	270	175	12	3	460	(77)	597
1987–1988	64	48	7	6	125	(21)	279	156	18	15	468	(79)	593
1988–1989	71	43	10	2	126	(23)	215	176	31	7	429	(77)	555
1989–1990	53	62	8	4	127	(20)	263	198	23	9	493	(80)	620
1990–1991	64	55	4	3	126	(21)	243	193	31	3	470	(79)	596
1991–1992	72	67	4	1	144	(22)	280	215	13	7	515	(78)	659
1992–1993	65	67	8	3	143	(20)	306	218	37	14	575	(80)	718
1993–1994	82	68	2	2	154	(22)	298	221	17	2	538	(78)	692
1994–1995	59	65	2	2	128	(18)	319	247	11	4	581	(82)	709
1995–1996	66	63	9	4	142	(21)	249	256	20	12	537	(79)	679
1996–1997	91	108	11	1	211	(29)	277	224	14	2	517	(71)	728
1997–1998	102	90	11	0	203	(29)	264	213	26	2	505	(71)	708
1998–1999	105	104	13	4	226	(28)	278	267	24	3	572	(72)	798
1999–2000	70	96	11	0	177	(22)	311	303	24	6	644	(78)	821
2000–2001	86	144	10	0	240	(27)	283	341	29	4	657	(73)	897
2001–2002	54	108	14	2	178	(19)	301	391	47	5	744	(81)	922
2002–2003	132	57	20	0	209	(25)	478	126	34	2	640	(75)	849
2003–2004	143	52	13	13	221	(27)	396	145	27	27	595	(73)	816

[a] Excludes hunters in permit hunts.
[b] Local means reside in Unit 20D.

TABLE 11 Southwestern, southeastern, northwestern, and northeastern Unit 20D moose hunter success and mean days hunted[a], regulatory years 1986–1987 through 2003–2004

Regulatory	Successful hunters					Unsuccessful hunters				
year	SW	SE	NW	NE	Total	SW	SE	NW	NE	Total
1986–1987	3.8	3.0	5.3	4.1	3.9	5.5	10.5	6.1	7.0	6.0
1987–1988	4.4	7.3	4.8	3.9	4.7	5.3	7.5	6.7	6.5	6.1
1988–1989	4.6	6.2	5.3	4.5	5.0	5.9	6.3	5.8	6.5	6.0
1989–1990	4.7	4.5	4.1	5.1	4.6	9.7	5.7	5.9	5.3	5.9
1990–1991	4.9	6.6	3.9	6.5	4.7	3.5	5.6	5.8	6.3	5.9
1991–1992	6.0	4.9	5.5	4.2	5.6	5.9	7.0	6.8	5.6	6.3
1992–1993	4.7	5.7	5.4	4.9	5.0	5.9	5.1	6.8	5.2	6.2
1993–1994	5.4	4.4	6.2	7.5	5.7	6.2	7.5	6.6	9.4	6.5
1994–1995	5.1	6.3	5.9	4.2	5.4	5.9	4.9	6.2	7.2	6.1
1995–1996	7.2	5.4	5.6	4.5	6.3	6.9	4.9	7.2	7.2	6.9
1996–1997	4.9	4.2	4.9	6.6	5.0	6.5	5.0	6.7	6.9	6.6
1997–1998	5.3	5.3	6.9	5.1	5.9	7.0	5.5	6.7	7.4	6.9
1998–1999	6.9	9.2	7.6	3.8	7.3	8.0	5.3	7.1	9.5	7.7
1999–2000	5.5	8.5	5.7	4.5	5.7	7.7	7.8	7.8	5.4	7.7
2000–2001	5.1	4.6	5.3	4.0	5.0	6.9	7.9	6.9	5.9	6.9
2001–2002	6.4	5.4	6.0	5.5	6.1	6.9	5.8	7.2	5.5	6.9
2002–2003	5.8	6.4	7.0	1.5	6.3	6.7	5.2	6.9	7.3	6.8
2003–2004	6.0	5.7	6.3	4.5	6.0	7.1	5.6	7.1	4.3	6.9

[a] Excludes permit hunt harvest.

TABLE 12 Unit 20D moose harvest[a] chronology percent by month/day, regulatory years 1990–1991 through 2003–2004

Regulatory year	Harvest chronology percent by month/day				
	9/1–9/5	9/6–9/10	9/11–9/15	Unk	*n*
1990–1991	57	20	23	0	109
1991–1992	57	22	16	5	141
1992–1993	50	30	18	3	139
1993–1994	42	26	28	4	154
1994–1995	45	25	22	8	128
1995–1996	41	20	33	6	138
1996–1997	51	23	23	3	208
1997–1998	44	24	30	3	196
1998–1999	44	30	24	2	223
1999–2000	41	30	24	5	175
2000–2001	48	28	23	1	246
2001–2002	44	34	21	2	172
2002–2003	36	37	22	5	174
2003–2004	39	30	30	1	158

[a] Excludes permit hunt harvest.

TABLE 13 Unit 20D moose harvest percent[a] by transport method, regulatory years 1987–1988 through 2003–2004

Regulatory year	Harvest percent by transport method									*n*
	Airplane	Horse	Boat	3- or 4-wheeler	Snowmachine	Other ORV	Highway vehicle	Airboats	Unknown	
1987–1988	8	2	27	20	0	8	29		6	126
1988–1989	10	2	24	18	0	9	29		9	126
1989–1990	10	3	29	13	0	12	29		3	127
1990–1991	7	0	25	20	0	12	33		3	118
1991–1992	13	3	23	25	0	8	24		3	144
1992–1993	8	1	26	18	<1	8	36		1	143
1993–1994	6	1	30	25	1	7	29		2	154
1994–1995	4	2	29	28	0	11	23		3	128
1995–1996	6	2	33	18	0	8	28		5	142
1996–1997	4	<1	27	28	0	8	31		2	210
1997–1998	5	1	23	32	0	5	31	<1	2	202
1998–1999	7	1	26	26	0	4	34	0	2	227
1999–2000	5	2	21	38	0	5	27	1	2	177
2000–2001	5	1	19	34	0	5	32	2	2	240
2001–2002	3	2	25	34	0	7	24	2	4	178
2002–2003	9	0	16	39	0	4	30	2	1	178
2003–2004	4	2	18	41	0	3	26	2	4	160

[a] Excludes permit hunt harvest.

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MOOSE MANAGEMENT REPORT

From: 1 July 2001
To: 30 June 2003[a]

LOCATION

GAME MANAGEMENT UNIT: 20E (10,680 mi^2)

GEOGRAPHIC DESCRIPTION: Charley, Fortymile, and Ladue River drainages

BACKGROUND

During the 1950s to the early 1960s, following federal predator control, the moose population in Unit 20E increased to a minimum of 12,000 moose. The population declined rapidly during 1965 through 1976, reaching an estimated low of 2200 moose. During 1976–2003 the moose population in Unit 20E remained at low densities (0.2–0.6 moose/mi^2). Gasaway et al. (1992) evaluated the roles that predation, nutrition, snow, harvest, and disease played in maintaining the moose population at low densities. They concluded that predation was the primary limiting factor and that other variables had little to no impact.

During the early 1980s, in response to declining moose and caribou populations, the Alaska Department of Fish and Game initiated 2 predator management programs. Between 1981 and 1983 the wolf population was reduced by 54% in a 3800-mi^2 area of Unit 20E using a combination of aerial shooting by the department and public trapping. In addition, grizzly bear hunting regulations were liberalized in 1981, causing moderate increases of grizzly bear harvest in portions of the subunit, probable local declines in grizzly bear numbers, and changes in the bear population age and sex structure (Gardner 1999).

Between 1981 and 1990 the moose population increased by about 4–9% per year. The increase was probably due to combined effects of favorable climatic conditions, reduced predation, and an increased number of alternate prey, i.e., Fortymile caribou. During this period the moose population did not increase beyond the ability of wolves and bears to maintain the population at low densities, and between 1990 and 2003 it remained at 0.5–0.6 moose/mi^2.

Prior to 1992, moose in Unit 20E were primarily hunted by local residents and residents from Fairbanks and Southeast Alaska. Historically, harvest was low in relation to the moose population and was largely restricted to the Taylor Highway corridor and the Mosquito Fork

[a] This unit report also includes data collected outside the reporting period at the discretion of the reporting biologist.

drainage. During 1992–2003, more hunters from Southcentral Alaska traveled to Unit 20E to hunt moose in response to more restrictive moose hunting regulations in the southcentral units and for the opportunity to hunt both moose and caribou in Unit 20E.

During the 1960s, high moose densities supported a long hunting season and a bag limit of 1 moose. As moose numbers began to decline, harvests were first reduced by shortening the season length in 1973 and then by eliminating cow seasons in 1974. However, the population continued to decline throughout Unit 20, and in 1977 moose hunting in Unit 20E (then a portion of Unit 20C) was terminated. A 10-day bulls-only season was opened in 1982 and continued until 1991. The season was lengthened to 15 days during 1991–2000. In response to an increasing number of hunters and harvest, in most of Unit 20E, the fall moose season was split in 2001 into a 5-day August season and a 10-day September season and was managed under a registration permit. This season structure is currently in place.

MANAGEMENT DIRECTION

MANAGEMENT GOALS

- Protect, maintain, and enhance the moose population in concert with other components of the ecosystem.
- Continue sustained opportunities for subsistence use of moose.
- Maximize sustained opportunities to participate in hunting moose.
- Maximize opportunities for the nonconsumptive use of moose.

MANAGEMENT OBJECTIVE

- Maintain a posthunting ratio of at least 40 bulls:100 cows in all survey areas.

INTENSIVE MANAGEMENT OBJECTIVES

In that portion of Unit 20E within the Fortymile and Ladue River drainages.

- Population: 8000–10,000 moose.
- Harvest: 500–1000 moose annually.

METHODS

POPULATION STATUS

We conducted moose population estimation surveys in southwestern and western Unit 20E (Mosquito Flats and Tok West Study Areas) in 1981, 1988, 1992, 1995 and 1998–2003 and in southeastern and central Unit 20E (Ladue River and Tok Central Study Areas) in 1992, 1996, and 1998–2003. We used the standard Gasaway et al. (1986) technique in 1981 and 1989 and modifications of that technique developed by Mark McNay (ADF&G, personal communication) in 1992 and by Rod Boertje, Jay Ver Hoef, and Craig Gardner (ADF&G) in

1995–1996. During 1998–2003 we used a Geostatistical Population Estimator (GSPE; Ver Hoef 2001), a modification of the standard Gasaway et al. (1986) technique.

The Ladue River Study Area was expanded in 1998 and again in 2000 to include more area than was being intensively hunted during the fall and winter moose seasons. To reduce confusion regarding comparison of survey results with the smaller Ladue River Study Area, we renamed this larger area, Tok Central.

During 1999 Yukon Department of Renewable Resources staff used the spatial correlation sampling technique (Ver Hoef 2001) in a 900-mi^2 area adjacent to our Tok Central study area. This allowed us to expand the moose population size and composition estimates to include more of the White and Ladue River drainages in the Yukon.

These data were used to determine population trends and composition in the study areas and to estimate moose numbers in the entire unit. The Mosquito Flats, Tok West, and Tok Central (Alaska and Yukon) areas differed in habitat quality, wolf and grizzly bear population densities, and hunter use. These variables were considered when extrapolating moose density estimates throughout the unit.

To evaluate the effects on moose of a nonlethal wolf control program (Boertje and Gardner 1999), we surveyed portions of western Unit 20E and northern Unit 20D (referred to as the Tok West Study Area) using the GSPE (Ver Hoef 2001). This area will be surveyed annually until 2005 to determine moose population and composition trends. The nonlethal wolf control program was conducted in western Unit 20E, northern Unit 20D, and eastern Unit 20B during 1997–2001. Wolf populations are currently in the recovery stage and are expected to return to pretreatment levels in the next few years.

During 1997, 1999 and 2003 moose population trend and composition was monitored in northern Unit 20E within the Yukon–Charley Rivers National Preserve by the National Park Service (NPS) (J. Burch, NPS, personal communication).

COMPOSITION SURVEYS

Sex and age composition was estimated in 2–10 traditional trend count areas during October and November 1993, 1994, 1996, and 1999, and in 1995, 1996, 1998, and 1999–2003 while conducting population estimation surveys in the Tok West and Tok Central study areas. All moose observed were classified as large bulls (antlers >50 inches), medium bulls (antlers larger than yearlings but <50 inches), yearling bulls (spike, cerviform, or small palmate antlers without brow separation), cows without calves, cows with 1 calf, cows with 2 calves, lone calves, or unidentified moose.

HARVEST

Harvest was estimated using harvest report cards, (after reminder letters were sent) and in 2001–2003, within most of Unit 20E, by registration permit reports. Information obtained from the reports was used to determine total harvest, harvest location, hunter residency and success, harvest chronology, and transportation used. Harvest data were summarized by

regulatory year (RY), which begins 1 July and ends 30 June (e.g., RY02 = 1 Jul 2002–30 Jun 2003).

HABITAT ENHANCEMENT

Natural wildfires were managed under the Alaska Interagency Fire Management Plan. Three prescribed burns were ignited in Unit 20E during 1997 and 1998 using aerial firing from a Ping-Pong sphere dispenser. Firing activities were conducted following a strict burn prescription developed specifically for each of the 3 areas and based on the Fire Weather Index and Fire Behavior Prediction modules of the Canadian Forest Fire Danger Rating System (Stocks et al. 1989).

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Population Size

During 1981–1995, 4 population estimation surveys were conducted in a 964–2978 mi^2 (2500–7700 km^2) area in southwestern Unit 20E (Gardner 1998). The annual rate of increase during 1981–1987 was 1.08, and during 1988–1995 it was 1.01, indicating the moose population in southwestern Unit 20E increased through the 1980s until 1988 and remained relatively stable during 1989–1995.

In 1992 we conducted the first population estimation survey in a 735-mi^2 area in southeastern Unit 20E. The estimated moose population was 652 ± 21% (90% CI). Mean density was 0.89 moose/mi^2, 29% greater than the density found in the adjacent southwestern portion of the subunit. We conducted a population estimate survey in southeastern Unit 20E again in 1996 (944 ± 26%, 90% CI), but results are not directly comparable because during 1992 we did not estimate a sightability correction factor. Based on estimates generated from observed moose, moose numbers in this area increased by 12.9% during 1992–1996, an annual rate of increase of 1.03.

The 1998 Tok Central (Alaska only) moose population and density estimates were 1444 ± 22% (90% CI) and 0.52 moose/mi^2. Including the Yukon data, the 1999 density estimate within the White and Ladue River drainages and along the Alaska Highway in both Alaska and Yukon was 0.48 moose/mi^2. These data indicate little difference between moose densities across the border and that little change in moose numbers occurred between 1998 and 1999. The Tok Central survey area was expanded during 2000–2003, resulting in a larger portion of the survey area that was made up of high quality moose habitat (previously burned areas). This resulted in higher density estimates within this survey area. Therefore, data collected in the Tok Central survey area prior to 2000 should not be directly compared to data collected from 2000 through 2003.

NPS conducted population estimation surveys in northern Unit 20E within the Yukon–Charley Rivers National Preserve west of Washington Creek and south of the Yukon River in 1994 and 1997. They found about 0.30 moose/mi^2 during both years (Bruce Dale, ADF&G,

personal communication). The NPS surveyed both north and south of the Yukon River in 1999 and 2003 and the estimate for the entire area was 0.37 and 0.22 moose/mi^2 respectively.

No formal surveys were conducted in the northeastern portion of Unit 20E (approximately 15% of the unit). I estimated moose population size (0.3 moose/mi^2) in that area by using a combination of data, including the amount of suitable moose habitat, harvest, and the number of moose concentration areas in comparison to the areas in the subunit that were sampled.

Combining the population estimates, the 2003 population estimate for Unit 20E was 4000–4800 moose, with an estimated density of 0.5–0.6 moose/mi^2 of moose habitat (8000 mi^2). The 2001 estimate was 4500–5300 moose. Poor calf and yearling survival for the past 4 years are the main reasons for the population decline.

The Alaska Board of Game identified the moose population within the Fortymile and Ladue River drainages as important for high levels of human consumptive use under the Intensive Management Law (AS 16.05.255[e]–[g]). This designation means the board must consider intensive management if a reduction in harvest becomes necessary because of dwindling moose numbers or productivity. The board established the moose population objective within the Fortymile and Ladue River portion of Unit 20E at 8000–10,000 moose with an annual harvest objective of 500–1000 moose. In RY03 neither the population nor harvest objectives were met and, based on moose, caribou, wolf, and grizzly bear population trends, these objectives will not be met in the foreseeable future unless predation is reduced.

Gasaway et al. (1992) reported that the Unit 20E moose population was maintained at a low density dynamic equilibrium (0.1–1.1 moose/mi^2) by wolf and grizzly bear predation and that habitat, harvest, and disease were not limiting population growth. They determined predator management was necessary to increase the moose population and to maintain it at a higher abundance level. There has been much public and scientific debate over whether wolf control combined with public grizzly bear harvest would cause a moose population increase in Unit 20E. Gasaway et al. (1992) recommended altering wolf and bear predation simultaneously. Reducing predation of only 1 species may result in compensatory predation by another species. Opponents of wolf control argue that reducing wolves will not benefit the moose population because grizzly bears are the primary predator on calves, which is the major limiting factor. Additional arguments have been made that wolf control was tried and failed in Unit 20E. They based their conclusions on results of the wolf control program conducted in Unit 20E during 1981–1983. Unfortunately, this program was terminated prematurely because of political decisions.

To simulate potential consequences of different methods of intensive management on moose numbers in the Fortymile–Ladue drainages, I modeled current population status and trend data for moose and their predators using the McNay and DeLong (1998) Predprey model. Results indicate that the Unit 20E moose population continues to be primarily limited by grizzly bear predation on calves. Gasaway et al. (1992) estimated that between 1981 and 1988, 52% of calf mortality was due to grizzly bears. In order for the model to track current population status, grizzly bears had to cause 58–62% of the calf mortality during 1997–2003.

The effects of wolf predation on the Unit 20E moose trend are expected to increase. During 1997–2001, wolf control activities reduced wolf numbers in the western portion of the unit. Wolf numbers will increase substantially in that area once the effects of wolf control end. Throughout the unit, wolf numbers will probably increase because caribou numbers are high and increasing, allowing for high wolf productivity and survival. It is highly probable that the Unit 20E moose population will decline to 0.2–0.3 moose/mi^2 unless wolf numbers, grizzly numbers, or both are reduced.

Assuming grizzly bear predation rates remain relatively constant during the next 3 years, the model predicts that the effect of nonlethal wolf control will be minimal on the population trend (annual growth rates = 0.97–1.00). Calf:cow ratios will range in the high teens to low 20s:100 cows and the bull:cow ratio will decline due to harvest.

Moose numbers would remain stable or slightly increase (1–3% annually) if the number of grizzly bears or their predation efficiency were reduced by 2–3% annually and wolf predation increased at the expected rate. A more substantial decrease in grizzly bear numbers (25%) could cause a 5–10% increase in moose numbers. This was the objective for liberalizing the Unit 20E grizzly bear regulations in 1981, i.e., to reduce the grizzly bear population through harvest.

If the intensive management law is implemented in Unit 20E, bear predation rates on calves must be reduced before substantial increases in the moose population can occur. Even with liberalized grizzly bear harvest regulations during 1982–2003, harvest was not high enough to consistently improve moose calf survival.

To reduce the effects of grizzly bear predation on calves, either the number of bears would have to be reduced to a level at which compensatory bear predation is no longer a factor, or the efficiency with which bears kill calves would have to be reduced. Based on observations during moose calf mortality studies where grizzly bears were translocated (C.L. Gardner, ADF&G, personal communication), fewer bears can kill more calves per bear. There is probably a point at which bear reduction is great enough that fewer calves will be killed by grizzly bears. Since females with cubs are protected from harvest but are efficient predators on moose calves (Boertje et al. 1988), a greater percentage of males and unaccompanied females would have to be removed from the population. Beginning in RY02, grizzly bear regulations became more liberal by not requiring a trophy tag fee for Alaska residents.

Model results continue to support the recommendation that moderate reductions of both wolves and bears would better suit moose management in Unit 20E compared with strong reductions in either predator population (Gasaway et al. 1992). If 30–35% of the wolf population was harvested annually and grizzly bear numbers were reduced by 25%, moose numbers could increase 3–12% annually.

Population Composition

During 2001–2003 we collected composition data in the Tok West and Tok Central survey areas (Table 1). Calf recruitment was poor, ranging between 10–25 calves:100 cows. Calf survival to 5 months has been poor (≤25:100) since 1998.

The Unit 20E bull:cow ratio remained above the management objective, but was declining in portions of the unit. The number of hunters has increased since 1992, and access into Unit 20E increased as new trails and landing areas were pioneered. In the most popular hunting areas (Nine Mile Trail, Mitchell's Ranch, and along the Yukon River and Taylor Highway) bull populations declined most noticeably, but still met or exceeded the management objective of 40:100 during this reporting period.

Modeling data indicate that if calf recruitment remains below 30 calves:100 and harvest levels remain the same, the bull:cow ratio will decline. Even with hunting season and access restrictions, I expect the bull population to decrease and the bull:cow ratio to decline below 50 bulls:100 cows in many areas of the unit by 2005.

Distribution and Movements

Moose are distributed throughout Unit 20E below elevations of 4500 feet. Most radiocollared moose during 1984–1986 moved seasonally from lowland summer habitat to upland rutting areas, where they remained until March. In fall 1988, 1992, 1999, and 2000 early deep snowfall (>22 inches) appeared to cause moose to move to lower elevations during November.

MORTALITY

Harvest

Seasons and Bag Limit. Season and Bag Limits are summarized in Table 2.

Alaska Board of Game Actions and Emergency Orders. During the spring 2000 meeting, the Board of Game created a registration permit hunt in Unit 20E, excluding the Middle Fork Fortymile River. The board also split the moose season into 2 periods: 24–28 August and 8–17 September, except within the Yukon River drainage, where the season became 24–28 August and 5–25 September. The board also stipulated that a hunter could hunt both moose and caribou, but not hold a registration permit for both species at the same time. These actions were in response to increased harvest due to an increasing number of hunters in most of Unit 20E. Also in spring 2000, the board set the intensive management population and harvest objectives for the Unit 20E moose population within the Fortymile and Ladue River drainages as 8000–10,000 moose and 500–1000 harvested. During the spring 2002 meeting, the board reduced the season within the Yukon River drainage to match the season in the remainder of Unit 20E (24–28 Aug and 8–17 Sep). To encourage hunters to harvest more grizzly bears to benefit moose calf survival, the board also eliminated the grizzly bear tag fee requirement for resident hunters in Unit 20E except in the Yukon–Charley Rivers National Preserve.

Hunter Harvest. During RY01–RY03 the reported fall harvest in Unit 20E averaged 145 (129–169) bulls (Table 3), or about 3.3% of the 2003 estimated early winter population. The average reported harvest for the 5 years prior to RY01, or RY96–RY00, was 136 (117–150) even though the number of moose hunters in Unit 20E increased from an average of 487 during RY96–RY00 to 829 during RY01–RY03. Therefore, it appears the season structure implemented in RY01–RY03 achieved the desired result of stabilizing the harvest of moose in Unit 20E. Probable causes for the higher hunter participation include 1) hunters were

displaced by stricter regulations throughout Southcentral Alaska, especially in nearby Unit 13; 2) the Fortymile caribou season was open concurrently with the moose season, which attracted hunters interested in hunting both species simultaneously; 3) maintaining a 1 bull bag limit with relatively liberal season dates gave hunters a false impression about the number of moose in the area; and 4) more hunters came to the area looking for large antlered bulls.

The Board of Game created 2 winter drawing permit hunts (DM794 and DM796) within the Ladue River Controlled Use Area in spring 1994. The harvest objective was to allow greater hunting opportunity in an area that supported a high number of bulls (bull:cow ratio >60:100) but was rarely hunted due to difficult access in the fall. We attempted to manage these hunts so winter harvest would not affect the bull numbers in areas commonly hunted during the fall; however, our efforts were largely unsuccessful.

During RY95–RY99, 10 winter permits were offered annually for DM794. Due to the low number of permits and difficult access, harvest was 0–4 bulls annually. Even though harvest was low, it was concentrated in areas that were hunted in the fall because of easier access. Many unit hunters voiced concern that the winter harvest was affecting local moose numbers. In response, the number of permits was reduced to 8 in 2000 and to 6 in 2001. During 2001, 5 of the 6 permit recipients participated and all were successful. Harvest was again concentrated in areas hunted in the fall and the number of permits was reduced to 3 for RY02–RY03. Unfortunately, the DM794 hunt area does not lend itself for subdivision to distribute hunters into areas not hunted during the fall. Reducing the number of permits to 3 should limit any impacts on moose numbers in this area regardless of where harvest occurs. During RY02–RY03, only 1 bull was harvested. Conversations with participants during RY02–RY03 indicated that hunters were searching for larger bulls during these years than participants in previous years. I plan to continue to encourage hunters to travel to the more remote areas and attempt to harvest large, trophy bulls (antlers ≥60 inches) that are not accessible in the fall.

During RY95–RY98, 50 winter permits were offered annually for DM796. Access into the central portion of this area is difficult, but the southern and northern portions are readily accessible by several snowmachine trails. Moose hunters used these trails extensively in the fall. During the first 2 seasons (RY95 and RY96) only 4 bulls were taken each year. There was no impact on bull numbers. During RY97 and RY98, 14 (35 hunters) and 10 (20 hunters) bulls were taken, and harvest was concentrated along the 2 trails used extensively by hunters during the fall hunt. This level of harvest reduced the number of large bulls along these trails.

In RY99 we attempted to reduce the winter harvest of moose along these trails by reducing the number of DM796 permits to 35 and by requesting that all DM796 permit recipients consider hunting more remote areas. The harvest was 8 bulls and half were taken in more remote areas. In RY00 the number of DM796 permits was reduced to 25 and use of the 2 most popular trails into the area was prohibited. Fifteen hunters participated, taking 9 bulls, 6 of which were taken in remote areas.

Historically, most hunters accessed the DM796 hunt area by snowmachine and the 2 best trails to access the remote areas were the 2 that were closed in RY00. In RY01 we established a hunt area within the permit area but allowed any method of legal access, including use of all trails. Because the hunt area was more confined, the number of permits was reduced to 10 to

guard against overharvest. During RY01, 7 hunters participated, taking 3 bulls. To ensure against DM796 affecting moose numbers, the required hunt area will be changed periodically but will be located away from areas most hunted in the fall. During RY02 and RY03, 3 and no bulls were harvested, respectively.

Antler data indicates that restricting hunters to bulls with at least 50-inch antlers in Unit 20E would not stop a declining bull:cow ratio. Much of the bull population is composed of mature bulls that would be vulnerable to harvest. Calf recruitment has been poor since the 1970s, resulting in few bulls growing into the 50-inch class each year.

Maintaining a sustainable moose harvest has become a great management challenge in Unit 20E. Our primary concern is the increasing number of hunters. Regulatory changes reduced high incidental take of moose by caribou hunters, but as harvest regulations became more restrictive in other units along the road system, more moose hunters were displaced to Interior units including Unit 20E. Our objective by splitting the season and shortening the season along the Yukon River was to reduce hunter efficiency resulting in lower harvest. If these harvest management methods do not continue to hold the harvest at a stable level, more restrictive regulations will be necessary.

Hunter Residency and Success. Of the 138, 169, and 129 bulls harvested during the general season in RY01, RY02, and RY03, 64%, 70% and 63% were taken by nonlocal Alaska residents (Table 4). Prior to 1992, most nonlocal hunters were from Interior and Southeast Alaska, but since RY92 most of the nonlocal hunters were from Southcentral Alaska. Nonlocal hunters made up 55%, 60% and 66% of the hunters during RY01–RY03. Local hunters represented 21–34% of the hunters and took 16–24% of the harvest. Nonresident hunters were prohibited from hunting moose in Unit 20E during RY83–RY90. During RY91–RY00, nonresidents represented 8% of the hunters and accounted for an average of 9% of the harvest. During RY01–RY03, nonresidents represented 10–13% of the hunters and took 12–20% of the harvest.

Hunter success was 19%, 18%, and 16% during RY01, RY02, and RY03, respectively. The success rate has been in a decline since RY98. The average success rate declined from 28% during RY93–RY97 to 20% during RY98–RY03. This decline is primarily due to a declining moose population and implementation of more restrictive regulations. During RY01–RY03, success rates of local residents averaged 13% compared with a 20% success rate for nonlocals and 22% for nonresidents.

Harvest Chronology. During RY90–RY94, an average of 35 bulls were harvested during 1–6 September (Table 5), representing 40% (range = 27–50%) of the fall harvest. During RY95–RY00, harvest total during this time period remained the same (36 bulls) but represented only 25% (16–33%) of the harvest. Apparently, as hunter numbers increased in Unit 20E, a greater percentage chose to hunt later in the season.

In an attempt to maintain or reduce the fall harvest in Unit 20E, during RY01 the hunting season in most of the unit was split into 2 periods: 24–28 August and 8–17 September. Our intention was to reduce harvest during the 5-day August season to less than the harvest during the previous 1–5 September season. During RY93–RY00, 16–42 ($\bar{x}$ = 31) bulls were

harvested during 1–5 September. In RY01–RY03, 7–14 ($\bar{x}$ = 10) bulls were harvested during 24–28 August, an average 68% reduction.

During RY91–RY98, harvest during 16–25 September in northern Unit 20E was 10–20 bulls annually. Harvest increased to 27–29 bulls during 16–25 September in RY99–RY01. The greater harvest could be attributed to more nonlocal Alaska resident hunters. During informal interviews we identified the reason for this increased harvest: The hunting season was open later than anywhere else along the road system. This portion of Unit 20E supports the lowest density of moose (0.3–0.37 moose/mi^2) in the unit and this increase was not sustainable. Beginning in RY02 the hunting season in northern Unit 20E was shortened to end the same date as the remainder of the unit.

Transport Methods. During RY01–RY03 we saw a significant increase in the percent of the moose harvest reported by hunters using 4-wheelers. It increased from a relatively stable average of 28% (range of 22–32%) during RY92–RY00, to an average of 43% (range of 38–49%) during RY01–RY03 (Table 6). In addition, the proportion of the harvest by hunters using highway vehicles declined significantly from an average of 21% during RY92–RY00 to an average of 10% during RY01–RY03. Again, this is an indication of the decline in the moose population and implementation of more restrictive regulations. The number of hunters using the other transportation types and harvest associated with these transportation types remained relatively constant.

In combination with the increasing number of hunters, increasing access by 4-wheelers is a growing management concern. The increasing quality and dependability of the machines allowed hunters to access areas that had previously been refugia for moose. This group of hunters tends to have a greater effect on local populations of moose because they tend to concentrate their efforts in smaller areas along trail systems rather than spreading effort more evenly over the landscape.

Other Mortality

Predation by wolves and grizzly bears was the greatest source of mortality for moose in Unit 20E and maintained the population at a low density (0.42–0.53 moose/mi^2). Using the model presented by McNay and DeLong (1998), I estimated about 33% of the postcalving moose population was killed by wolves and grizzly bears each year and harvest was about 1.6%. The percentage killed by predation increased during RY00–RY03 probably due to the increased wolf population in the central, northern, and eastern portions of the subunit.

HABITAT

Assessment

Availability of browse in Unit 20E is not limiting moose population growth. Past browse studies found that use of preferred browse plants was less than 5% (Boertje et al. 1985). The greatest expanse of excellent habitat is in the southeastern portion of the unit resulting from 2 large wildfires (>1,000,000 acres) during the mid 1960s. This area supports the greatest moose densities in the unit (0.7–1.0 moose/mi^2). Prescribed fires and wildfires burned over 400,000 acres in Unit 20E during 1998–1999. Moose used these areas during winters 2001–2002 and 2002–2003. Habitat quality in these areas is expected to improve during the next

15 years. There are still areas within the northeastern portion of the unit where the habitat has degraded to poor moose habitat due to wildfire suppression activities during the 1970s and 1980s.

Enhancement

The Alaska Interagency Fire Management Plan restored a near-natural wildfire regime to over 60% of Unit 20E. Under the plan, most state and federal land was assigned limited fire protection. This agreement allowed nearly 300,000 acres to burn naturally during 1998 and 1999. Nearly all land selected by or conveyed to Native corporations was assigned modified or full-suppression status. However, Native corporations in Units 20E and in adjacent Unit 12 have recently consented to allow fire on their land, except in areas with marketable timber. More acceptance of fire as a management tool has occurred in local communities because of the well-known increase in moose numbers near Tetlin and Tok as a result of the 1990 Tok wildfire. This change in attitude allowed us to prescribe burn 90,000 acres during 1998 and 1999 in central Unit 20E. Costs were 35 cents/acre for the 52,000-acre East Fork burn, 46 cents/acre for the 7000-acre Mosquito Flats burn, and 38 cents/acre for the 31,000-acre Ketchumstuk burn. Moose densities in these areas are expected to increase within 5–15 years.

CONCLUSIONS AND RECOMMENDATIONS

During RY01–RY03 the moose population in Unit 20E declined and was estimated at 0.41–0.45 moose/mi^2 in fall 2003. Research has shown that predation by wolves and grizzly bears was the primary factor limiting the moose population. Wolf predation on moose is expected to increase during the next few years. Wolf numbers are increasing in most of Unit 20E because of elevated productivity and survival and relatively low harvest. I recommend both wolf and grizzly bear numbers be reduced if the objective is to substantially increase moose numbers. Reducing either grizzly or wolf numbers would allow the moose population to remain stable or possibly increase slowly, depending on the level of reduction. Combined wolf and bear predation took about 33% of the postcalving moose population annually.

In an attempt to reduce effects of predation on the area's moose population, grizzly bear hunting regulations were liberalized in 1981. As a result, bear harvest increased and possibly caused bear numbers to decline and altered the male age structure toward younger bears. Moose calf survival increased during 1982–1989. Modeling indicated that the reduced bear population may have increased adult moose survival but was inadequate to consistently improve calf survival. We do not know how much a grizzly bear population must be reduced before the predation rate on moose calves will decline substantially. However, modeling predicts the moose population in Unit 20E could grow 8–10% annually if grizzly bear predation rates on calves were reduced 25% in combination with 20–25% wolf harvest by trappers.

Human-induced mortality had little impact on the unit's moose population but caused some reduction in local bull populations. Annual harvest rates were historically less than 2% of the fall population estimate but increased above 2% in RY95 and have been about 2.5–3.0% during RY97–RY03. The bull:cow ratio declined in portions of Unit 20E due to moderate harvest rates in more accessible areas.

The number of moose hunters in Unit 20E increased significantly (P = 0.001) since RY91. Most of the additional hunters were from Southcentral Alaska. The preferred transportation type became 4-wheelers.

Regulation changes in RY01 appeared to reduce hunter success and stabilize harvest. Requiring hunters to choose either to hunt moose or caribou appeared to reduce the incidental take of moose by caribou hunters. During RY01–RY02 under this regulation fewer hunters took the opportunity to hunt both moose and caribou compared to RY93–RY95.

Increased hunter participation and harvest during the Unit 20E winter drawing permit hunts caused hunt management changes during RY99–RY01. The intent to allow hunters to hunt moose in areas inaccessible during fall was no longer met. In RY99 the number of DM796 permits was reduced but harvest distribution still did not meet the management intent. Additional reductions in permit numbers and hunt area occurred in RY00 but still was insufficient to meet hunt objectives. In RY01 the hunt was limited to a small portion of the permit area and only 10 permits were offered. This limited harvest to areas not hunted in the fall. To guard against overharvest, the hunt area will be moved periodically, based on harvest success and moose population trends. The number of DM794 permits was reduced in RY01 because harvest amount and distribution became a concern.

More community acceptance of fire has occurred since the late 1990s in Unit 20E. During 1998 and 1999, 3 prescribed burns covering about 90,000 acres were completed in areas that traditionally supported high moose densities. In addition, over 300,000 acres were allowed to burn by wildfire in 1999. Under the current Division of Forestry and Bureau of Land Management leadership, the interagency fire management plan has a great chance of benefiting wildlife and people.

The Unit 20E moose objective to maintain a posthunting ratio of at least 40 bulls:100 cows in all survey areas was met during this report period. Population trends were monitored and necessary changes to hunt structure were implemented. Habitat enhancement programs were designed and will be presented to the Interagency Fire Team for possible implementation. Hunting seasons and bag limits were established that allowed maximum hunting opportunity and met subsistence needs. Moose-watching opportunities were shared with visitors and local residents and several oral presentations were given annually to local schools and tourist groups. The intensive management objectives of a population of 8000–10,000 moose and annual harvest of 500–1000 moose in the Fortymile and Ladue River drainages were not met. Before the intensive management objectives can be met, wolf and grizzly bear predation on moose must be reduced.

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TABLE 1 Unit 20E aerial moose composition counts, fall 1988–2003

Year	Bulls:100 Cows	Yearling bulls:100 Cows	Calves:100 Cows	Calves	Percent calves	Adults	Moose observed	Moose/hr
1988[a]	78	13	22	117	11	931	1048[a]	30
1989[b]	56	11	43	43	21	158	201	22
1990[b]	64	9	30	105	16	566	671	30
1991[b]	65	14	28	120	14	714	834	42
1992[c]	59	11	17	19	12	141	160	
1992[d]	75	15	28	32	14	200	232	
1993[b]	63	10	28	126	15	727	854	40
1994[c]	74	16	23	65	12	488	553	48
1995[e]	70	16	15	29	8	329	358	
1996[f]	61	10	19	44	10	377	421	
1996[b]	56	6	27	47	15	270	317	45
1997[b]	61	14	26	70	14	438	508	49
1998[g]	64 (53)[h]	18 (10)[h]	19 (23)[h]	36	13	242	278	
1998[i]	59 (51)[h]	14	23 (26)[h]	67	15	383	450	
1999[g]	80 (74)[h]	16 (17)[h]	22 (14)[h]	27	7	338	365	
1999[b]	54	13	17	38	10	340	378	60
2000[g]	60	11	14	44	8	517	561	
2000[i]	49	11	21	37	11	310	347	
2001[g]	76	9	14	38	7	493	531	
2001[i]	51	6	10	39	6	585	624	
2002[g]	59	10	25	38	10	326	364	
2002[i]	71	8	20	37	9	359	396	
2003[g]	64	9	15	27	8	328	355	
2003[i]	53	5	11	20	7	277	297	

[a] Mosquito Flats Study Area sampled using stratified random sampling (Gasaway et al. 1986).
[b] Various trend count areas were sampled using contour sampling.
[c] Mosquito Flats Study Area sampled using superstratification sampling.
[d] Ladue River Study Area sampled using superstratification sampling (Mark McNay, ADF&G, personal communication).
[e] Mosquito Flats Study Area sampled using prestratification sampling (Jay Ver Hoef and Rod Boertje, ADF&G, personal communication).
[f] Ladue River Study Area sampled using prestratification sampling (Jay Ver Hoef and Rod Boertje, ADF&G, personal communication).
[g] Tok West sampled using geostatistical population estimator sampling (Ver Hoef 2001).
[h] Number in parenthesis is the observed ratio.
[i] Tok Central sampled using geostatistical population estimator sampling (Ver Hoef 2001).

TABLE 2 Unit 20E moose hunting seasons and bag limits, regulatory years 2001–2002 and 2002–2003

Regulatory year	Area	Season		Bag limit
2001–2002 and 2002-2003	Unit 20E Fortymile.	Resident:	Registration 24–28 Aug Registration 8–17 Sep Drawing 1–30 Nov	1 bull by permit RM865, or 1 bull by permit RM865, or 1 bull by permit DM794–DM796 in the Ladue River Controlled Use Area.
		Nonresident:	8–17 Sep	1 bull with 50-inch antlers or antlers with 4 or more brow tines on at least 1 side by permit RM865.
2001–2002	Unit 20E draining into the Yukon River upstream from and including the Boundary Creek drainages and the Taylor Highway from Mile 145 to Eagle.	Resident:	Registration 24–28 Aug Registration 5–25 Sep	1 bull by permit RM865, or 1 bull by permit RM865.
		Nonresident:	Registration 5–25 Sep	1 bull with 50-inch antlers or antlers with 4 or more brow tines on at least 1 side by permit RM865.
	Unit 20E draining into the Middle Fork Fortymile River upstream from the drainage of the North Fork Fortymile River.	Resident:	24–28 Aug 8–17 Sep	1 bull, or 1 bull.
		Nonresident:	8–17 Sep	1 bull with 50-inch antlers or antlers with 4 or more brow tines on at least 1 side.
	Remainder of Unit 20E.	Resident:	Registration 24–28 Aug Registration 8–17 Sep	1 bull by permit RM865, or 1 bull by permit RM865.
		Nonresident:	Registration 8–17 Sep	1 bull with 50-inch antlers or antlers with 4 or more brow tines on at least 1 side by permit RM865.
2002–2003	Unit 20E draining into the Middle Fork Fortymile River upstream from the drainage of the North Fork Fortymile River.	Resident:	24–28 Aug 8–17 Sep	1 bull, or 1 bull.
		Nonresident:	8–17 Sep	1 bull with 50-inch antlers or antlers with 4 or more brow tines on at least 1 side
	Remainder of Unit 20E.	Resident:	Registration 24–28 Aug Registration 8–17 Sep	1 bull by permit RM865, or 1 bull by permit RM865, or 1 bull by permit DM794–DM796 in the Ladue River Controlled Use Area.
		Nonresident:	Registration 8–17 Sep	1 bull with 50-inch antlers or antlers with 4 or more brow tines on at least 1 side by permit RM865.

[a] 50-inch antlers defined as having a spread of at least 50 inches or at least 4 brow tines on at least 1 side.

TABLE 3 Unit 20E moose harvest and accidental death, regulatory years 1990–1991 through 2003–2004

Regulatory year	Harvest by hunters							Drawing permit hunts		Accidental death		
	Reported				Estimated							
	M (%)	F (%)	Unk	Total	Unreported	Illegal	Total	DM794	DM796	Road	Total	Total
1990–1991	46 (100)	0 (0)	0	46	0–5	5–15	9–22			0	0	54–61
1991–1992	90 (99)	0 (0)	1	91	0–5	5–15	9–22			0	0	100–113
1992–1993	68 (99)	0 (0)	1	69	0–5	5–15	9–22			1	1	79–92
1993–1994	128 (99)	0 (0)	1	129	0–5	5–15	5–20			0	0	134–149
1994–1995	93 (99)	0 (0)	1	94	0–5	5–15	5–20			0	0	99–114
1995–1996	139 (99)	0 (0)	1	140	0–5	5–10	5–15	0	4	0	0	149–159
1996–1997	116 (99)	0 (0)	1	117	0–5	5–10	5–15	2	4	0	0	128–138
1997–1998	144 (99)	1 (1)	0	145	0–5	5–10	5–15	4	14	0	0	168–178
1998–1999	145 (96)	0 (0)	5	150	0–5	5–10	5–15	1	10	0	0	166–176
1999–2000	127 (97)	0 (0)	4	131	0–5	5–10	5–15	3	9	0	0	148–158
2000–2001	135 (100)	0 (0)	0	135	0–5	5–10	5–15	2	6	0	0	148–158
2001–2002	137 (99)	0 (0)	1	138	0–5	5–10	5–15	5	3	0	0	151–161
2002–2003	169 (99)	0 (0)	1	169	0–5	5–10	5–15	1	3	0	0	175–185
2003–2004	129 (100)	0 (0)	0	129	0–5	5–10	5–15	0	0	0	0	134–144

TABLE 4 Unit 20E moose hunter residency and success during the general season, regulatory years 1990–1991 through 2003–2004

Regulatory year	Successful					Unsuccessful					Total hunters
	Local[a] resident	Nonlocal resident	Nonresident	Unk	Total (%)	Local[a] resident	Nonlocal resident	Nonresident	Unk	Total (%)	
1990–1991	16	28		2	46 (16)	65	176	2	6	249 (84)	295
1991–1992	34	54	3	0	91 (21)	112	219	9	3	343 (79)	434
1992–1993	15	45	4	5	69 (24)	52	135	9	24	220 (76)	289
1993–1994	38	77	14	0	129 (30)	93	188	17	2	300 (70)	429
1994–1995	27	58	9	0	94 (19)	97	272	17	7	393 (81)	487
1995–1996	36	93	9	2	140 (31)	72	208	34	4	318 (69)	458
1996–1997	40	70	7	0	117 (29)	97	165	24	0	286 (71)	403
1997–1998	42	85	18	0	145 (30)	112	189	31	0	332 (70)	477
1998–1999	47	91	12	0	150 (32)	76	205	39	2	322 (68)	472
1999–2000	36	77	17	1	131 (23)	98	299	30	4	431 (77)	562
2000–2001	36	84	15	0	135 (26)	98	255	33	1	387 (74)	522
2001–2002	33	88	16	1	138 (19)	222	323	58	4	607 (81)	745
2002–2003	29	119	20	1	169 (18)	200	449	92	3	741 (82)	944
2003–2004	21	81	26	1	129 (16)	143	448	74	4	669 (84)	798

[a] Residents of Unit 12 and Units 20E and eastern Unit 20D are considered local residents. Major population centers are Eagle, Chicken, Boundary, Northway, Tetlin, Tok, Tanacross, Slana, and Dot Lake.

TABLE 5 Unit 20E moose harvest chronology by month/day during the general hunt, regulatory years 1990–1991 through 2003–2004

Regulatory year	Harvest chronology by month/day						Total[a]
	8/15–8/28	9/1–9/6	9/7–9/13	9/14–9/20	9/21–9/27	9/28–10/5	
1990–1991		20	9	7	6	0	46
1991–1992		25	26	22	14	0	91
1992–1993		29	28	5	5	0	69
1993–1994		52	40	24	8	0	129
1994–1995		47	21	16	8	0	94
1995–1996	0	46	58	27	3	0	140
1996–1997	1	33	49	23	6	0	118
1997–1998	1	48	50	36	6	0	144
1998–1999	0	35	78	23	6	2	150
1999–2000	0	30	57	28	13	0	131
2000–2001	1	22	61	41	8	0	135
2001–2002	14	0	71	43	7	0	138
2002–2002	7	0	103	51	2	0	169
2003–2004	8	3	76	32	0	1	129

[a] Difference between total and summation of harvests by week represents moose taken on unknown dates.

TABLE 6 Unit 20E moose harvest and percent by transport method during the general season, regulatory years 1990–1991 through 2003–2004

Regulatory year	Harvest and percent by transport method								
	Airplane	Horse	Boat	3- or 4-wheeler	Snowmachine	Other ORV	Highway vehicle	Unknown	*n*
1990–1991	7 (15)	3 (7)	10 (22)	6 (13)	0 (0)	8 (17)	7 (15)	5 (11)	46
1991–1992	11 (12)	2 (2)	18 (20)	10 (11)	0 (0)	15 (16)	35 (38)	0 (0)	91
1992–1993	17 (25)	1 (1)	4 (6)	21 (30)	1 (1)	7 (10)	15 (22)	3 (4)	69
1993–1994	31 (24)	0 (0)	15 (12)	34 (26)	0 (0)	15 (12)	32 (25)	2 (2)	129
1994–1995	24 (26)	0 (0)	14 (15)	26 (28)	0 (0)	13 (14)	15 (16)	2 (2)	94
1995–1996	29 (21)	0 (0)	19 (14)	39 (28)	1 (1)	16 (11)	34 (24)	2 (1)	140
1996–1997	26 (22)	3 (3)	18 (15)	26 (22)	0 (0)	13 (11)	30 (26)	1 (1)	117
1997–1998	29 (20)	3 (2)	13 (9)	46 (32)	0 (0)	15 (10)	36 (25)	3 (2)	145
1998–1999	32 (21)	0 (0)	23 (15)	40 (27)	1 (1)	12 (8)	41 (27)	1 (1)	150
1999–2000	31 (24)	1 (1)	26 (20)	37 (28)	0 (0)	19 (15)	15 (11)	2 (2)	131
2000–2001	29 (21)	2 (1)	28 (21)	40 (30)	0 (0)	14 (10)	20 (15)	2 (1)	135
2001–2002	23 (17)	0 (0)	14 (10)	68 (49)	0 (0)	15 (11)	18 (13)	0 (0)	138
2002–2003	44 (26)	1 (1)	17 (10)	65 (38)	4 (2)	20 (12)	16 (9)	3 (2)	170
2003–2004	37 (29)	2 (2)	7 (5)	53 (41)	0 (0)	15 (12)	12 (9)	3 (2)	129